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THE BREEDING VALUE OF SELECTED INBRED CLONES OF STRAWBERRIES WITH RESPECT TO THEIR VITAMIN C CONTENT[1]

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The strawberry breeding program at the University of Minnesota has included systematic inbreeding since 1922 and since 1929 has emphasized the selection of superior inbreds and their use in crosses. Selections from seedling progenies descended from standard varieties through one to three generations of selfing and selection have been used as parents in several experiments. The plants in one of these studies, a combining-ability experiment, fruited for the first time in 1948. Certain of the available populations were used in the present study of breeding behaviour with respect to the vitamin C content of the fruit.

The vitamin C content of strawberries is influenced by many factors, including sunlight, soil, and fruit size, maturity, and portion of the berry tested (2, 7). Berries grown in the shade, or upon shaded plants, contain less vitamin C than those grown in the sun, according to several workers (5, 9). Small berries have been found to have a higher concentration than large berries, and mature, deep red berries higher concentration than less mature, medium red berries (12).

Several workers (2, 3, 5, 7, 11,12) have reported large differences in vitamin C content among varieties, ranging from extremes of 41 mgm. to 142 mgm. of ascorbic acid per 100 gm. of fresh fruit. Some work has been done on the inheritance of vitamin C production in strawberries. Hansen and Waldo (6) in 1944 suggested that certain varieties were more influential than others when used as parents for high vitamin C, the Marshall, Clarke, and Progressive varieties and *Fragaria chiloensis* Duch. having the highest prepotency of the varieties and species studied. Slate and Robinson (12) in 1946 found a general positive relationship between the vitamin C content of the parent and the mean of its offspring and suggested the Beacon variety as a parent in breeding for high vitamin C content. In 1947 Darrow *et al.* (4), and Ezell *et al.* (5), concluded that it is quite possible to breed varieties for either higher or lower vitamin C than any now available.

MATERIALS AND METHODS

The strawberry populations used for this study were from crosses made in 1946. The object of the original experiment (10) was to test the combining-ability, with respect to vegetative vigour and resistance to leaf spot,

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of clones from several inbred strawberry lines originating from different varieties. Nine clones were chosen with regard to their leaf-spot reaction. Each of these was selfed and crossed with all others. Their progenies were planted in 2 complete randomized blocks. The plants were spaced 4 feet 6 inches on the square and allowed to produce runners without restriction. The parents were planted in an adjacent block and, while under similar conditions, were not strictly comparable with their progeny.

The first fruit from the parental clones was harvested in June, 1948, and analysed for vitamin C content. Of the 9 original parents, 5 were chosen for study on the basis of their vitamin C content. No selection had been made previously for vitamin C content in any of these lines. The breeding numbers, source, and number of generations selfed were as follows: 3819–22, Marshall, 3 generations selfed; 3632–2, Dunlap, 3 generations selfed; 33142–9, Minnehaha, 2 generations selfed; 3315–7, Chaska, 2 generations selfed; and 382–89, Howard 17 (Premier), hereafter referred to as Premier, 1 generation selfed. These parents will be called Marshall 3, Dunlap 3, Minnehaha 2, Chaska 2, and Premier 1 in the remainder of the paper. The direction in which the crosses were made and the sizes of the populations studied are shown in Table 1.

TABLE 1.—LIST OF SELFS AND CROSSES, AND THE SIZE OF POPULATIONS STUDIED

Parentage	Number of Plants	Parentage	Number of Plants
Marshall 3 × self	16	Chaska 1 × self	19
× Dunlap 3	22	× Marshall 3	35
× Minnehaha 2	29	× Dunlap 3	36
Dunlap 3 × self	12	× Minnehaha 2	25
× Marshall 3	4	× Premier 1	23
Minnehaha 2 × self	22	Premier 1 × self	31
× Dunlap 3	41	× Marshall 3	35
× Premier 1	32	× Dunlap 3	30
Total			412

Fully ripe, undamaged strawberries were harvested for vitamin C analyses from June 13 to June 19. Up to 50 gm. of berries, with calyx attached, were harvested from individual plants and immediately placed in numbered cellophane bags. The bags were heat sealed, making them air-tight, and placed in a freezer at −10° F. within 3 hours from the time of harvest. The samples were stored at −10° F. until analysed. Further samples from the parent plants were taken between the above dates.

Samples of 5 standard varieties were harvested from the University of Minnesota Fruit Breeding Farm, Excelsior, or the Mayo Forestry and Horticultural Research Institute, Rochester, or from both. From 3 to 6 independent determinations were made on each sample and the results compared with those reported in the literature.

In order to estimate the amount of vitamin C lost from the berries under the conditions of storage used, samples of the Premier variety in a yield trial were taken from each of 3 replicates. Each sample was divided

into 10 sub-samples and packaged in individual cellophane bags. At the beginning, end, and three times during the period of analysis, 2 samples from each of the 3 replicates were drawn at random and analysed.

The vitamin C analyses were made according to Ballentine (1). Samples of about 30 gm. (from 15 gm. to 35 gm.) of the frozen fruit were hulled, counted and weighed to 0.1 gm. They were mascerated with about 30 ml. of 4 per cent metaphosphoric acid in a semi-micro Waring Blendor. The resulting slurry was quantitatively transferred to a 100 ml. graduate and brought up to volume with metaphosphoric acid. Where less than 25 gm. of fruit were available the final volume was adjusted accordingly. The slurry was immediately filtered and the vitamin C content of the filtrate determined by the potassium iodate method on at least two 10 ml. aliquots.

The statistical analysis of the data was made according to Snedecor (13). The analyses of the plot means made use of the usual analysis of variance adjusted for the unequal numbers of plants per plot by the general method of fitting constants.

RESULTS

Comparison with Values Previously Reported

The means of the vitamin C determinations of 6 samples from each of 5 varieties are shown in Table 2 (Column 1E and 1R). The vitamin C content of these varieties, as reported in the literature, is listed for comparison.

TABLE 2.—A COMPARISON OF VITAMIN C DETERMINATIONS OF STANDARD VARIETIES WITH THOSE REPORTED IN THE LITERATURE

Variety	Mean vitamin C content in mgm. per 100 gm. as reported by*:					
	1E	1R	2.	3.	4.	5.
Aberdeen	—	40.1	40.9	50	41	—
Dunlap	103.8	—	72.2	—	—	79
Marshall	81.5	78.7	67.4	—	49	—
Midland	—	68.9	60.8	86	64	—
Premier	78.0	58.7	66.6	63	54	—

* 1E — Fruit from Excelsior
1R — Fruit from Rochester
2. — Ezell, Darrow, Wilcox, and Scott (5)
3. — Darrow, Wilcox, Scott, and Hutchins (4)
4. — Slate and Robinson (12)
5. — Mayfield and Richardson (8)

While it is not possible to compare these results critically, it will be noted that those samples harvested from Rochester had vitamin C contents closely approaching those reported in the literature. The 3 standard varieties harvested from Excelsior all gave vitamin C contents which appear to be higher than the results previously reported. This discrepancy might be explained by the fact that during the period of harvest light intensity was high at Excelsior. There was also a lack of moisture during the ripening period which may have reduced the water content of the fruit.

Loss of Vitamin C While in Storage During the Period of Analysis

The means of 6 determinations for each of 5 dates on the Premier variety harvested from Rochester are shown in Table 3.

TABLE 3.—VITAMIN C CONTENT OF CONTROL DETERMINATIONS FOR DATE OF ANALYSIS. (PREMIER VARIETY FROM ROCHESTER, MINN.)

Date of Analysis	Vitamin C content (Mean of 6 determinations)
	mgm. per 100 gm.
July 15	57.6
21	59.7
28	57.7
August 7	59.6
18	58.5

The analysis of variance, using individual samples rather than the means of two samples (a total of 29 degrees of freedom rather than 14 degrees of freedom) gave an F value less than expectation for "dates" source and an F value of 7.6 for "replicates" source of variation. There were, therefore, no differences among the determinations of the Premier variety during the month of analysis under the conditions of this experiment and the first and last determinations were directly comparable.

Vitamin C Content of the Parents, the Self, and the Cross Populations

The mean vitamin C content of the parental clones, the self, and the cross populations from these parents are presented in Table 4. The parents used in this study fell into 2 distinct categories with respect to the vitamin C

TABLE 4.—MEAN VITAMIN C CONTENT OF SELF AND CROSS POPULATIONS IN MGM. PER 100 GM.

Parents	Marshall 3	Dunlap 3	Minnehaha 2	Chaska 2	Premier 1
Mean of parental Clones	126.0±3.3	116.5±4.5	109.7±4.2	85.3±3.1	79.6±3.8
Premier 1	129.2	104.6	108.8	96.7	102.1*
Chaska 2	118.3	106.3	113.8	104.6	
Minnehaha 2	134.9	115.7	110.7		
Dunlap 3	131.3	117.2			
Marshall 3	128.7				
Mean of means of crosses	128.4	114.5	118.3	108.8	109.8

* Means of selfed populations are underlined

L.S.D. at	Between Means of: Crosses and Selfs (Body of Table)	Means of Crosses (Foot of Table)
5 per cent	11.2	7.2
1 per cent	15.6	9.8

content of their fruit. Marshall 3, Dunlap 3, and Minnehaha 2 were considered to have very high vitamin C contents while Chaska 2 and Premier 1 were medium in their vitamin C content. These two groups were significantly different. Differences within these groups were not demonstrated.

The vitamin C content of the strawberry populations studied was highly variable. The extent of this variability is shown in Table 5, which presents the frequency distribution in percentage of the plants with vitamin C contents in the classes indicated. The crosses tended to be more uniform than the selfs with respect to the vitamin C content of their fruit, but not significantly so. The variability of the strawberry populations with respect to vitamin C content was due to the variability of samples from the same plant, the variability of a chemical determination, and actual differences among plants within a given family. The actual differences among plants within a family may be attributed to genetical and environmental differences.

It was estimated by use of the true variance that the environmental variation between plots of the same cross family was 2.1 per cent of the total variation; the environmental variation between plots of the same self family was less than expectation. Therefore much of the within-family variation may be attributable to genetic differences between plants within a family. The estimate of the true variance showed that 67.4 per cent

TABLE 5.—FREQUENCY DISTRIBUTION IN PERCENTAGE OF POPULATION TOTALS. VITAMIN C CONTENT OF STRAWBERRY FRUIT. (MGM. PER 100 GM.)

Population	Class Centres (mgm. per 100 gm.)										
	65	75	85	95	105	115	125	135	145	155	165
Marshall 3 selfed			6		19	13	19	13	12	12	6
× Dunlap 3					12	15	19	19	27		8
× Minnehaha 2				4		10	24	31	17	4	10
× Chaska 2			6	6	14	20	34	17		3	
× Premier 1				9	14	14	17	9	20	9	8
Dunlap 3 selfed	8	8		8		9	42		25		
× Marshall 3					12	15	19	19	27		8
× Minnehaha 2			5	7	24	34	13	10	3	2	2
× Chaska 2		8	14	17	25	9	19	8			
× Premier 1			27	13	23	13	20	4			
Minnehaha 2 selfed	6		14	9	17	29	20	3	2		
× Marshall 3				4		10	24	31	17	4	10
× Dunlap 3			5	7	24	34	13	10	3	2	2
× Chaska 2		4	4	16	32	12	12	12	4		4
× Premier 1		6		19	31	19	19	6			
Chaska 2 selfed			16	26	21	26	11				
× Marshall 3			6	6	14	20	34	17		3	
× Dunlap 3		8	14	17	25	9	19	8			
× Minnehaha 2		4	4	16	32	12	12	12	4		4
× Premier 1	4	5	26	22	26	13	4				
Premier 1 selfed		7	16	29	19	16	7	3	3		
× Marshall 3				9	14	14	17	9	20	9	8
× Dunlap 3			27	13	23	13	20	4			
× Minnehaha 2		6		19	31	19	19	6			
× Chaska 2	4	5	26	22	26	13	4				

of the total variability was found between plants within a family compared with only 30.5 per cent found between families of selfs and families having one parent in common. The conclusions to be drawn from these estimates indicate that the parents were highly heterozygous for vitamin C content. However, the parents had undergone no selections for vitamin C content in the course of the breeding work.

A consideration of the mean vitamin C contents of the various self and cross families presented in Table 4 shows that there were significant differences among families. There was a close association ($r = .75$, P less than .01) between the mean of a cross population and the mean of the 2 parents involved in the cross. There was a similar association ($r = .80$, P less than .01) between the mean of a cross and half the sum of the means of the selfed populations derived from the parents involved in the cross. In no case were the means of the crosses significantly greater than the means of the higher parents, although in several cases they were equal to the higher parent. It may be concluded that high vitamin C content of strawberry fruit is partially dominant to low vitamin C content with the parental material used. There was no evidence of heterosis for this character. Marshall 3 appeared to transmit its high vitamin C content particularly well, especially in combination with Minnehaha 2, Dunlap 3, and Premier 1, while Minnehaha 2 transmitted its high vitamin C content well in all crosses except with Premier 1.

Since a vigour rating had already been made on these plants, and since the weight per fruit of the samples used for analyses was available, simple correlations between these three characteristics were made. The results of these correlations are presented in Table 6. It is of some interest to note the significant, but low, negative correlation between weight per fruit and vitamin C content. This had previously been reported within varieties and apparently holds true among varieties. The large fruit tended to contain less vitamin C per unit weight than did the small fruit. The correlation between plant vigour and weight per fruit was low, but significantly positive as would be expected.

TABLE 6.—CORRELATIONS (r) BETWEEN VITAMIN C CONTENT, WEIGHT PER FRUIT, AND PLANT VIGOUR

Character:	Vitamin C Content			Weight per fruit		
Population:	Selfs	Crosses	Total	Selfs	Crosses	Total
Vigour	−.140	−.078	−.032	+.027	+.189**	+.292**
Weight per Fruit	−.077	−.182**	−.103*			

* Significant at 5 per cent
** Significant at 1 per cent

DISCUSSION

The results of these studies indicate that not only is high vitamin C partially dominant to low vitamin C but the parents, when selfed, produce some plants having a higher vitamin C content than their own. The crossed populations also contain some plants having a higher vitamin C

content than do the parents, and in some cases higher than any found in the selfed populations from their parents. This indicates a recombination of favourable genes within a parent or from both parents. Therefore the development of a strawberry variety containing more vitamin C than any variety now available could probably be accomplished without difficulty. The fact that there is a negative, but low, correlation between fruit size and vitamin C content should not seriously hinder such a program. The appearance of large fruited, high vitamin C individuals may occur frequently enough to allow for the selection of other desirable characteristics within this group of individuals. The matter of vigour needs little consideration if inbred clones are used as parents, because it has been shown that all crosses with these particular inbred selections, at least, produce progeny with satisfactory vigour.

The advantages to be gained by a study of the selfed progeny from the parental material are shown in the added information regarding the genotypes of these parents. Another advantage from selfing, not demonstrated in this study, is the selection of desirable lines within these selfed populations. The within-family variance measures the variability of the selfed families. Such a statistic, applied to selfed families produced from plants with families of known variance, should be of greater use in assessing the uniformity of any such selected line. It would then be possible not only to study the direction in which the mean was being selected but also to measure the change in variability brought about by such selection. It is quite conceivable that if the individuals within the selfed families here reported were selfed, some would produce families having equal, and some having less, variability than the line from which they were derived. This information, together with the means of the characteristic being studied would be of use in assessing their respective breeding values.

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REFERENCES

1. Ballentine, Robert. Determination of ascorbic acid in citrus fruit juices. Ind. Eng. Chem., Anal. Ed. 13 : 89. 1941.
2. Burkhart, Leland, and R. A. Lineberry. Determination of vitamin C and its sampling variation in strawberries. Food Res. 7 : 332-337. 1942.
3. Burrell, R. C., and Virginia R. Ebright. The vitamin C content of fruits and vegetables. Jour. Chem. Educ. 17 : 180-182. 1940.
4. Darrow, G. M., Marguerite S. Wilcox, D. H. Scott, and Margaret C. Hutchins. Breeding strawberries for vitamin C. Jour. Hered. 38 : 363-365. 1947.
5. Ezell, Boyce D., George M. Darrow, Marguerite S. Wilcox, and D. H. Scott. Ascorbic acid content of strawberries. Food Res. 12 : 510-526. 1947.
6. Hansen, Elmer, and George F. Waldo. Ascorbic acid content of small fruits in relation to genetic and environmental factors. Food Res. 9 : 453-461. 1944.
7. Kirk, Mary Mann, and Donald K. Tressler. Ascorbic acid content of pigmented fruits, vegetables, and their juices. Food Res. 6 : 395-411. 1941.

REFERENCES—Concluded

8. Mayfield, Helen L., and Jessie E. Richardson. Ascorbic acid content of strawberries and their products. Mont. Agric. Expt. Sta. Bull. 412 : 1-16. 1943.
9. McCrory, S. A. Vitamin C content of strawberries. North and South Dakota Hort. 19 : 31-32. 1946.
10. Rao, H. S., and A. N. Wilcox. The combining ability of certain inbred and selected clones of the strawberry with respect to vegetative vigor and resistance to leaf spot (*Mycosphaerella fragariae* (Tul.) Sacc.). *In preparation.*
11. Satterfield, G. Howard, and Mary Yarbrough. Varietal differences in ascorbic acid (vitamin C) content of strawberries. Food Res. 5 : 241-245. 1940.
12. Slate, George L., and W. B. Robinson. Ascorbic acid content of strawberry varieties and selections at Geneva, New York, in 1945. Proc. Amer. Soc. Hort. Sc. 47: 219-223. 1946.
13. Snedecor, George W. Statistical methods (4th ed.) Iowa State College Press, Ames, Iowa. 1946.

DDT RESIDUES ON CELERY RESULTING FROM DUST TREATMENTS FOR CONTROL OF THE TARNISHED PLANT BUG[1]

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INTRODUCTION

In Manitoba, "black joint" of celery, attributed to the feeding activity of the tarnished plant bug, *Lygus oblineatus* (Say), has caused considerable concern. DDT was shown in 1944 to be very effective against the nymphs and adults of this insect (1, 4). Satisfactory control has been obtained with 3 to 5 per cent DDT dusts (2, 3). Because DDT dusts are being used by celery-growers in Manitoba to control this insect, it is desirable to know the amount of DDT residues present at harvest-time and when the celery is marketed.

Applications of DDT dust were made to celery crops throughout the growing season, and the deposits of DDT remaining on the leaf-stalks at harvest time were determined. It appeared possible that DDT deposits might accumulate differentially within the celery heads, especially because overhead irrigation was being used. Accordingly, the distribution of the residues at different locations on the celery plants was measured separately. The reduction of residues caused by post-harvest trimming and commercial washing prior to marketing was also investigated.

APPLICATION OF INSECTICIDE

The dusts were applied independently by a market-gardener using field machinery. All dusting was carried out during the evening. The outlets of the dusting machine were set about 6 inches above the celery plants, so that the dust would be driven well into the foliage and heads.

The applications were as follows:—

(1) In 1947 a 3 per cent DDT dust was applied at 35 lb. per acre on July 15 and August 1, 14, and 23, making a seasonal total of 4.2 lb. of actual DDT per acre.

(2) In 1948, early-harvested celery received a 5 per cent dust at 50 lb. per acre on July 8, and a 3 per cent dust at 75, 35, and 35 lb. per acre on July 20 and August 5 and 14, respectively, making a seasonal total of 6.8 lb. of DDT per acre.

(3) In 1948, late-harvested celery received the treatments applied to early-harvested celery and 3 additional applications of 3 per cent dust at 35 lb. per acre on August 21 and 24 and September 3, making a seasonal total of 10.0 lb. of DDT per acre.

SAMPLING, AND ANALYSIS OF RESIDUES

In September, samples of celery were taken for residue analysis. In 1947, samples were taken 13 days after the last dust treatment; in 1948, 25 days and 4 days elapsed between the last dusting and the sampling of

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the early-harvested and the late-harvested celery, respectively. The series of analyses to determine the reduction of residues resulting from post-harvest processing was made on late-harvested celery 20 days after dust treatments had been completed.

In 1947, leaf-stalk samples were taken from 18 treated plants in the following manner. A celery-bed was selected and 2 outside leaf-stalks were removed from every third plant in a row. This whole sample was then divided into 3 sub-samples, each containing 12 leaf-stalks. Each leaf-stalk was divided into 2 "stalk zones", which have been termed "upper" and "basal". The upper zone comprised the portion of the leaf-stalk from the first node down to the top of the membranous structure that runs along the edge of each leaf-stalk in the basal region and serves to clasp firmly the inner stalks. The basal zone extended from this point to the top of the root. Thus the distribution of residues at 2 locations on the outside leaf-stalks of celery heads was measured. A control sample was prepared by taking 6 outside leaf-stalks from each of 2 whole plants that had not received treatment.

In 1948, 10 whole plants were selected at random from each of the treated beds. Each plant was arbitrarily divided into 3 stalk locations:—

(1) *Outermost*—the outer broad leaf-stalks that firmly surround the celery head;

(2) *Middle* —leaf-stalks midway between the outermost leaf-stalks and the heart;

(3) *Heart* —the first recognizable leaf-stalks next to the unfolded heart.

Two leaf-stalks were taken from each of these locations. The leaf-stalks were in turn divided, as in 1947, into 2 stalk zones. Thus the distribution of residues was determined at 6 places within the celery heads. Samples from each of the above-mentioned stalk locations and zones were composited for the 10 plants. Control samples were prepared in the same manner.

Preliminary steps in sample preparation consisted of removing the old, decumbent leaf-stalks surrounding the celery heads, cutting off the roots, and washing off any adhering soil. After the composite samples were prepared, they were weighed, and the DDT residues were removed with reagent grade benzene.

The reduction of residues on celery resulting from commercial washing was determined as follows: Sixteen days after the residues were measured on late-harvested celery, 20 plants that had been trimmed for market were obtained from crates in the warehouse. Half of these plants were washed with a "bunch washer", and then both lots were sampled by the system outlined. The bunch washer consisted of a travelling belt which carried the celery heads between two groups of 11 spray nozzles, one directed from above the moving celery, the other from below. Water emerged from the nozzles under a pressure of 300 lb. per square inch.

In 1947, the DDT residues from the upper and basal stalk zones were stripped into a large funnel, fitted with a tight plug of glass wool, and placed over a 200-ml. volumetric flask. While each portion of the stalk was slowly revolved over the funnel, a stream of benzene dispensed from

a wash-bottle was directed up and down the sides several times. After approximately 190 ml. of strippings were thus collected, 10 ml. of benzene were used to wash down the funnel.

In 1948, each composite sample, consisting of 150 to 200 gm. of celery, was placed in a glass-stoppered reagent jar and washed successively with 90, 45, and 45 ml. of benzene. The celery and benzene were shaken together for 2 minutes during each washing. The jar was emptied and rinsed with 20 ml. of benzene. The washings from each sample were filtered through glass wool into a 200-ml. volumetric flask.

To check the efficiency of the residue extraction method, 2 samples of celery from which the DDT residues had previously been extracted were re-washed with 50 ml. of benzene each and DDT analyses made. The results were negative for both samples.

Before determination, 2 gm. of anhydrous sodium sulphate were added to each 200 ml. of residue extract to dehydrate the sample and hasten clarification. The Schechter-Haller (6) spectrophotometric method was used for the DDT analyses. Results from the control samples were used to correct the values observed for treated celery.

RESULTS AND DISCUSSION

Several applications of DDT dust during the growing season produced high residues on celery, particularly at the base of the head, toward the periphery. As shown in Table 1, increased DDT residues on celery resulted when the total amount of DDT applied was increased. After more than 4.2 lb. of DDT per acre were applied in a season, residues exceeding the tentative tolerance level of 7.0 p.p.m. were found in the basal zones of the outermost and middle leaf-stalks.

Table 1.—Distribution of DDT residues on celery plants

Total DDT pounds per acre	Days last application to harvest	Stalk zone	Residues		
			Stalk location		
			Outermost (p.p.m.)	Middle (p.p.m.)	Heart (p.p.m.)
4.2[1]	13	Upper	1.37	—	—
		Basal	2.77	—	—
6.8[2]	25	Upper	2.20	0.85	0.45
		Basal	24.10	7.90	0.84
10.0[3]	4	Upper	4.60	2.23	2.20
		Basal	32.90	26.05	3.10

[1] 1947. Average of 3 sub-samples.
[2] 1948. Early-harvested celery.
[3] 1948. Late-harvested celery.

The application of 6.8 lb. of DDT per acre during the season resulted in a residue of 24.1 p.p.m. at the bases of the outermost leaf-stalks, 25 days after the last dust application. After 3 additional applications of 3 per cent dust at 35 lb. per acre, the residue, measured 4 days after the last

application, increased in this location to 32.9 p.p.m. At the bases of the middle leaf-stalks the corresponding residue increased from 7.9 to 26.0 p.p.m. In all cases, residual deposits were low on the upper zone at each stalk location. Residues were especially low on the leaf-stalks close to the heart.

It was expected that post-harvest processing would effect a significant reduction of residues, because the leaf-stalks designated as outermost were removed and the remainder of the head was washed before marketing. Accordingly, the middle and heart locations from the 2 lots of celery were sampled as before, as well as outer leaf-stalks that remained after removal of the outermost stalks. The results are shown in Table 2.

TABLE 2.—REDUCTION OF DDT RESIDUES ON TRIMMED LATE-HARVESTED CELERY EFFECTED BY WASHING

Treatment	Stalk zone	Residues		
		Stalk location		
		Outer (p.p.m.)	Middle (p.p.m.)	Heart (p.p.m.)
Unwashed	Upper	2.22	1.05	0.85
	Basal	11.72	4.40	1.32
Washed	Upper	1.12	0.61	0.58
	Basal	4.5	2.02	1.20
Per cent reduction	Upper	49.6	42.0	31.8
	Basal	61.6	54.0	9.1

In the 16-day interval between analyses, the residues at the middle and the heart locations, after a total seasonal dosage of 10.0 lb. of DDT per acre, dropped markedly (Table 2). It may be assumed that removal of the outermost leaf-stalks resulted in a significant reduction of the total residue. In addition, commercial washing removed from 40 to 60 per cent of the residue remaining after harvest.

Manalo *et al.* (5) determined DDT residues on celery after application of a 5 per cent DDT dust. The celery was divided into mature stalks and leaves and young stalks and leaves. The latter sample, after weighing, was washed with water to remove dirt, in a manner simulating preparation for the table. They found DDT deposits of 13.16 p.p.m. on the unwashed mature stalks and leaves 3 days after application and only 1.62 p.p.m. 18 days later. Young stalks and leaves that were washed before analysis retained DDT deposits of 0.5 and 1.22 p.p.m., respectively, after the same intervals.

In the present study, DDT residues were found to be differentially distributed throughout celery heads after frequent and heavy applications of dusts. The average total deposits increased progressively with rates of application. The residues were excessively high at the base of the head, especially toward the periphery. A reduction from 26.05 to 4.4 p.p.m. at the base of the middle stalk after 16 days' weathering was similar to that reported by Manalo *et al.* (5). Reduction during this period was less in other stalk locations. Appreciable amounts of DDT were removed with the outermost leaf-stalks at harvest, and commercial washing effected a further reduction.

SUMMARY

1. The distribution of DDT residues on celery plants treated with DDT dust at 4.2, 6.8, and 10.0 lb. of actual DDT per acre during the season was determined.

2. The DDT residues increased with rate of application and were found to be greater at the bases of the leaf-stalks than at the distal ends; deposits increased peripherally from the heart.

3. Application of 6.8 lb. of DDT per acre resulted in a deposit of 24.1 p.p.m. at the bases of the outermost leaf-stalks; when the seasonal application reached 10.0 lb., the residue in this location increased to 32.9 p.p.m. At the bases of the middle leaf-stalks the corresponding increase was from 7.9 to 26.0 p.p.m. In all cases, residual deposits were low on the upper zone at each stalk location. Residues on the leaf-stalks close to the heart were especially low.

4. Removal of the outermost leaves at harvest appears to produce a large reduction in the total DDT residue. Commercial washing accounted for a reduction of approximately 40 to 60 per cent of the remaining residue. The highest residual deposit left on the celery plants after washing was 4.5 p.p.m.

ACKNOWLEDGMENTS

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REFERENCES

1. Hills, O. A. DDT and other insecticides for the Say stinkbug and the tarnished plant bug. J. Econ. Ent. 37 : 142-143. 1944.
2. Hills, O. A. Memoranda of information on insecticides used against *Lygus* bugs on sugar beets grown for seed. U.S. Bur. Ent. and Plant Quar. E-635. 4 pp. 1945.
3. Hills, O. A., and K. B. McKinney. Comparative values of new insecticides for use against *Lygus* spp. and the Say stinkbug. U.S. Bur. Ent. and Plant Quar. E-648 19 pp. 1945.
4. Loftin, U. C. Results of tests with DDT against cotton insects in 1944. U.S. Bur. Ent. and Plant Quar. E-657. 6 pp. 1945.
5. Manalo, G. D., R. Hutson, and E. J. Benne. DDT residues on fruits and vegetables. Mich. Agr. Expt. Sta. Quart. Bull. 28 : 272-280. 1946.
6. Schechter, M. S., D. B. Soloway, R. A. Hayes, and H. L. Haller. Colorimetric determination of DDT (colour test for related compounds). Ind. Eng. Chem. Anal. Ed. 17 : 704-709. 1945.

DDT RESIDUES ON CURRANTS AND GOOSEBERRIES[1]

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INTRODUCTION

Experiments on the control of the currant fruit fly, *Epochra canadensis* Loew, have been carried out in Manitoba for several years. As a result of these experiments, DDT has been recommended for the control of the fly (1).

To determine the rates and number of applications required to obtain residues below the tentative tolerance level of 7.0 p.p.m., assessments of DDT residues were made on the treated fruit at harvest. Procedures for sampling the fruit, and extracting and measuring the residues, were investigated in 1946 and 1947. The information obtained suggested that DDT sprays applied after flowering, at high rates per acre, would probably result in excessively high residues on the ripe fruit. Accordingly, in order to build up effective DDT residues on the stems and foliage of the plants without increasing the deposition on the fruit, pre-bloom sprays were applied to the currants in the bud stage. In addition, post-bloom sprays were employed to increase and extend the usefulness of the DDT coverage. The first post-bloom spray was applied at the cessation of bloom; the second, when applied, followed 10 days later. The DDT residues on the ripe fruit resulting from different rates and combinations of pre- and post-bloom sprays were determined in 1948 and 1949. The interval from the last spray application to harvest and the precipitation during this period were considered.

METHODS

Field Plots and Arrangement

In 1948 the plots, which were located on several farms, each consisted of 10 to 20 currant or gooseberry bushes. Two treatments were used; each was applied to 4 plots, irrespective of the type of fruit. In 1949 each of the plots consisted of 14 red currant bushes. Six plots were arranged in each of 3 adjacent blocks. Six treatments were randomized within each block.

A 3-gal. compressed air sprayer was used to apply 50 per cent wettable DDT powder.

Sampling and Analysis

Fruit samples for residue analysis were taken when the fruit was ripe. A sample consisted of berries picked at random from one plot. The samples were quick-frozen shortly after collection and stored in a frozen state until the extractions were made.

In 1948, each 226-gm. sample was placed in a 1000-ml. Squibb separatory funnel and washed 3 times, once with approximately 95 ml. and then twice with 50-ml. portions of reagent grade benzene. The funnel was shaken continuously for 2 minutes during each washing. After the sample

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TABLE 1.—DDT RESIDUES IN PARTS PER MILLION ON RED CURRANTS (R) AND GOOSEBERRIES (G), 1948

Treatment		Fruit	Rainfall first spray to harvest inches	Days last spray to harvest	Residues
Number of sprays	Total DDT pounds per acre				
1 pre-bloom 1 post-bloom	2.3 1.15	R	4.87	47	1.63
		R	4.97	49	5.30
		R	4.97	49	2.50
		G	4.97	48	1.85
					Average 2.82
2 post-bloom	2.3	R	9.07	36	3.34
		R	4.97	37	2.67
		G	9.07	36	2.37
		G	4.97	37	2.90
					Average 2.82

was discarded the funnel was washed with approximately 10 ml. of benzene. The benzene extracts were filtered through glass wool to remove benzene-insoluble matter and were collected in a 200-ml. volumetric flask. Two grams of anhydrous sodium sulphate were then added to the flasks to hasten clarification of the residue extracts. Duplicate aliquots were taken and the DDT content was measured by the Schechter-Haller spectrophotometric method (2).

To determine the efficiency of the residue-stripping procedure, check tests were made on several samples. One additional wash with 50 ml. of benzene was given these samples, and only 0.0 to 0.05 p.p.m. was recovered after this extraction.

In 1949, 350-gm. samples were used. They were placed in a 1000-ml. Squibb separatory funnel and extracted successively with 125, 75, 75, and 50 ml. of reagent grade benzene; stripping was effected by shaking for 5, 3, 2, and 2 minutes, respectively. After a sample was discarded the separatory funnel, the filter funnel, and the glass wool were washed with 3 successive 15-ml. portions of benzene. The final volume of the total extract was adjusted to 350 ml., and 5 gm. of anhydrous sodium sulphate were added. Aliquots were taken and analysed for DDT as in 1948.

RESULTS AND DISCUSSION

The basic spray rate used in pre- and post-bloom sprays was 1.15 lb. of actual DDT per acre, which is approximately equivalent to an application of 0.5 lb. of DDT in 100 gal. of water, applied until the foliage drips. This rate has been recommended for the control of the currant fruit fly (1).

In 1948, 2 treatments were used, as shown in Table 1. The first consisted of 1 pre-bloom application of 2.3 lb. of DDT per acre, followed at cessation of bloom by an application of 1.15 lb. of DDT per acre. The second treatment consisted of 2 post-bloom sprays applied at 1.15 lb. of DDT per acre, 10 days apart.

As Table 1 shows, the DDT residues measured were below the tentative tolerance level of 7.0 p.p.m. No significant differences were established between the treatments.

In 1949, 6 treatments were employed. The pre-bloom rates were 0.0, 2.3, and 4.6 lb. of DDT per acre, and 2 post-bloom sprays were applied 10 days apart, one at the basic rate of 1.15 lb. of DDT per acre, as in 1948, and the other at double that rate, as shown in Table 2.

TABLE 2.—DDT RESIDUES IN PARTS PER MILLION ON RED CURRANTS 39 DAYS AFTER THE LAST SPRAY APPLICATION, 1949

Treatment		Rainfall first spray to harvest	Residues	
Total DDT pounds per acre				
Pre-bloom 1 spray	Post-bloom 2 sprays	inches	Maximum	Average[1]
0.0	2.3	4.54	3.53	2.71
2.3	2.3	6.38	4.07	3.01
4.6	2.3	6.38	5.22	4.22
0.0	4.6	4.54	7.42	6.11
2.3	4.6	6.38	5.46	5.22
4.6	4.6	6.38	7.42	6.21

[1] Difference required for significance at 5 per cent level: 1.88.

A comparison of Tables 1 and 2 shows that in both years 2 post-bloom applications at the basic rate resulted in residues approximating 3.0 p.p.m. In 1949, the pre-bloom sprays which preceded the 2 post-bloom sprays at the basic rate appear to have affected the residual deposits, but these differences are not significant. However, when the post-bloom spray rate was increased to 2.3 lb. of DDT per acre, residues were significantly increased. The averages fall into 2 groups corresponding to the post-bloom spray rates, and a significant difference in residues was demonstrated between these post-bloom spray rates.

The results obtained in both years show that pre-bloom sprays, as would be expected, have little influence on the residue at harvest. One post-bloom application of 1.15 lb. of DDT per acre gave rise to moderate residues. Residues resulting from 2 post-bloom sprays at the same rate were also moderate. But when 2 post-bloom sprays at double the basic rate, or 2.3 lb. of DDT per acre, were applied, residues approximated the tentative tolerance level of 7.0 p.p.m.

There was no evident relationship between the DDT residues on the harvested fruit and the period from the last spray application to harvest or the precipitation during this interval.

SUMMARY

1. In experiments designed to control the currant fruit fly, DDT residues were determined on harvested red currants and on gooseberries that had been treated with different rates and combinations of pre- and post-bloom sprays.

2. Pre-bloom sprays do not apparently influence residues at harvest. No significant difference was found between rates of 0.0, 2.3, and 4.6 lb. of DDT per acre.

3. The DDT residues after 1 post-bloom spray of 1.15 lb. of DDT per acre, which is equivalent to a thorough application of 0.5 lb. of DDT in 100 gal. of water, approximated 3.0 p.p.m. Two post-bloom sprays at the same rate, which have been recommended for control of the currant fruit fly, resulted in similar residues.

4. Residues were significantly increased and approached the tentative tolerance level of 7.0 p.p.m. when 2 post-bloom sprays were applied at 2.3 lb. of DDT per acre.

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REFERENCES

1. Allen, W. R., and R. D. Bird. Control of the currant fruit fly on the Canadian prairies. Canada Dept. Agr., Div. of Ent. Processed Publication No. 46. 1948.
2. Schechter, M. S., S. B. Soloway, R. A. Hayes, and H. L. Haller. Colorimetric determination of DDT (colour test for related compounds). Ind. Eng. Chem. Anal. Ed. 17 : 704-709. 1945.

FEEDING VALUE OF HORSEBEAN (*Vicia faba* L.) FOR CHICKS[1]

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An analysis of Canadian crop production reveals an inadequate volume of crops yielding vegetable protein of suitable biological quality for poultry feeding. Climatic adaptability is a foremost prerequisite in any crop whose production could be encouraged to meet this deficiency. The horsebean (*Vicia faba* L.) has already been grown to a limited extent in Quebec and the Maritime Provinces, and would appear to offer some promise in this development in these areas. It is a leguminous plant which is well adapted to a cool humid climate, the seed possesses fairly high protein content (25–27 per cent), and there is a good yield on any reasonably fertile soil.

McKee (20) and Bassot (4) stated that the horsebean possesses a high nutritive value for horses, cattle, swine and sheep. Belzile (5), however, concluded that horsebean was not superior to alfalfa, red clover or the field pea when fed as green forage. Woodman and Evans (25) reported that horsebean-pod meal had a very satisfactory digestibility, roughly two-thirds of the nutrients being available to ruminants. Paquette (21) studied, in vitro, the enzymatic digestibility of raw *Vicia faba* protein by pepsin and trypsin. He found that horsebean protein resembled soybean protein more closely than casein with respect to its digestibility. Zagami (26) reported that *Vicia faba* was adequate in vitamins B (B_1 by more recent classification) and E as shown by normal reproduction and absence of beriberi in rats.

Although the horsebean has demonstrated fairly high feeding value for larger animals, no experiments are reported in the literature on its nutritive value for poultry. Investigations were, therefore, undertaken to study the comparative feeding value of horsebean seed meal in chick rations.

EXPERIMENTAL

As a preface to experimental studies on the feeding value of the horsebean for chicks, it was necessary to have pertinent chemical data. Chemical analyses were carried out on two types of horsebean, small- and large-seeded varieties. A summary of chemical analyses is presented in Table 1.

The general pattern of all the chick experiments was the same for all trials. Male Barred Plymouth Rock chicks were started on a commercial ration for one week after which they were randomized into lots, wing-banded and confined to electrically heated wire floored battery brooders. The chicks were fed ad libitum throughout and had access to fresh water continuously. Body weight and feed consumption data were recorded each week. The basal horsebean meal ration for all trials is given in Table 2.

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TABLE 1.—COMPOSITION OF HORSEBEAN SEED

Component Dry Matter Basis	Large Seeded-Type Whole Seed	Small Seeded-Type Whole Seed
	%	%
Moisture	12.6	9.8
Crude Fat	1.6	1.7
Crude Protein	27.2	26.7
Crude Fibre	9.2	9.2
Ash	3.8	4.0
N-Free Extract	55.6	58.3
Calcium	0.14	0.15
Phosphorus	0.51	0.33
Thiamin (1)	225	220
Riboflavin (1)	175	210

[1] Gamma per 100 grams of dry matter.

TABLE 2.—COMPOSITION OF THE BASAL HORSEBEAN SEED MEAL RATION

Ingredients	Pounds
Hominy Feed	20
Ground Wheat	15
Ground Barley	10
Wheat Middlings	10
Alfalfa Meal (Dehyd.)	5
Brewers' Yeast	2
Ground Limestone	2
Salt (Iodized)	1
Horsebean Seed Meal	35
Fish Oil (1850 A, 400 D_3)	100 gm.
Riboflavin (Synthetic)	0.08 gm.
$MnSO_4 . 4H_2O$	6.0 gm.
Total[1]	100

[1] Calculated per cent Crude Protein.....18.5

Preliminary observations indicated that normal feather colour in Barred Plymouth Rock chicks was disturbed by high levels of horsebean meal feeding. In order to facilitate the scoring of this abnormal feathering, the chicks were fed a commercial ration for two weeks at the end of the experimental period. They were then examined with special attention to earlier feather development and pigmentation. The latter were scored separately on a basis where a rating of five indicated very poor feather development or total absence of black pigment while excellent feather growth and uniform barring were scored zero. To ensure unbiased scoring, chicks from all lots were mixed together and then drawn at random.

RESULTS AND DISCUSSION

Experiment 1

It is known that plant protein supplements cannot be fed as the sole source of protein in chick rations if maximum growth is desired. Vegetable proteins must be supplemented with varying amounts of animal protein to

TABLE 3.—COMPOSITION OF THE RATIONS FED IN EXPERIMENT I

Ingredient	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6	Lot 7
Basal Mixture	65.0	65.0	65.0	65.0	65.0	65.0	65.0
Hominy Feed	—	5.6	7.7	7.7	9.4	11.8	13.3
Raw Horsebean	35.0	17.5	17.5	17.5	17.5	17.5	17.5
Linseed Oil Meal[1]	—	11.9	—	—	—	—	—
Soybean Oil Meal	—	—	9.8	—	—	—	—
Sunflower Seed Oil Meal	—	—	—	9.8	—	—	—
Meat Meal	—	—	—	—	8.1	—	—
Fish Meal	—	—	—	—	—	5.7	—
Casein	—	—	—	—	—	—	4.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Calculated per cent Crude Protein	18.5	18.7	18.6	18.5	18.5	18.5	18.6

[1] Water Treated.

TABLE 4.—COMPLEMENTARY VALUE OF SOME PLANT AND ANIMAL PROTEIN SUPPLEMENTS IN A BASAL HORSEBEAN SEED MEAL RATION

Lot No.	Supplement Replacing Raw Horsebean Seed Meal	Final Weight at 6 Weeks[1]	Feed: Gain Ratio	Feathering	
				Growth Score	Achroma Score
		Grams			
1	Raw Horsebean Alone	160.2	4.11	3.4	3.9
2	Linseed Oil Meal[2]	219.5	3.44	1.7	0.8
3	Soybean Oil Meal	246.9	3.40	2.0	3.4
4	Sunflower Seed Oil Meal	324.4	3.11	0.9	1.3
5	Meat Meal	271.6	3.30	2.2	1.7
6	Fish Meal	349.0[3]	2.56	0.7	0.0
7	Casein	306.9	3.04	0.5	1.5

[1] Greatest necessary difference for significance of final weight is 51.0 at the 0.05 level.
[2] Water treated.
[3] Average of 4 chicks only due to accidental mortality.

induce best growth. Animal proteins, however, differ greatly in their ability to supplement plant proteins. Likewise, vegetable protein supplements exhibit different complementary values with each other in practical chick rations (9, 14, 15, 24).

The purpose of this initial experiment was to investigate the replacement value of some plant and animal protein supplements in the basal horsebean meal ration.

On the basis of chemical analyses, one-half of the horsebean seed meal protein was replaced in the basal ration (Table 2) by the following protein supplements: Linseed oil meal (water treated (17)), soybean oil meal, sunflower seed oil meal, meat meal, casein, and fish meal. Because of differences in protein content of the supplements added, adjustments were made at the expense of hominy feed (Table 3). Fourteen chicks per lot

TABLE 5.—COMPOSITION OF THE RATIONS FED IN EXPERIMENT 2

Ingredient	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6	Lot 7	Lot 8	Lot 9
Animal Protein per cent of Total Crude Protein	0.0	10.0	20.0	10.0	20.0	10.0	20.0	—	—
Basal Mixture	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Horsebean Seed Meal	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2
Hominy Feed	20.8	21.9	22.5	22.5	23.6	23.0	24.3	20.2	19.8
Soybean Oil Meal	9.0	4.0	—	4.0	—	4.0	—	7.5	6.0
Meat Meal	—	3.9	7.3	1.9	3.6	—	—	—	—
Fish Meal	—	—	—	1.4	2.6	3.0	5.5	—	—
Condensed Fish Solubles	—	—	—	—	—	—	—	2.0	4.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Calculated per cent Crude Protein	19.1	18.9	19.0	18.9	19.0	19.1	19.1	19.0	19.0

were fed on the experimental diets for a period of five weeks. The results of this experiment are summarized in Table 4.

The analysis of variance of the growth data shows the greatest necessary difference for significance to be 51.0 grams final body weight. Thus the replacement of horsebean meal of the basal ration with any of the above protein supplements gave a significant improvement in growth. Since 10 chicks in the lot receiving fish meal died through accident, data on the fish meal group were not included in the analysis of variance. However, the survivors showed the highest mean final body weight and therefore it is not unreasonable to assume that fish meal possesses excellent replacement value. From the growth data presented in Table 4 it would appear that fish meal, sunflower seed oil meal, and casein were the most effective complementary sources of protein in the basal ration for purposes of growth, and meat meal, soybean meal and water-treated linseed oil meal follow in decreasing order of value.

The amount of feed required to produce a unit of gain was greatly reduced by supplementing the horsebean meal with fish meal, casein and sunflower seed oil meal, and reduced to a lesser extent by supplementing with meat meal, soybean oil meal and linseed oil meal.

The data recorded on feathering show that the poor feather development and the absence of black pigment, principally on primary and secondary wing feathers and characteristic of the basal ration, were corrected by fish meal, and appreciably lessened by casein, meat meal, sunflower seed oil meal and water-treated linseed oil meal. Soybean oil meal failed to improve either feather growth or feather pigmentation. It is concluded that animal proteins generally, and fish meal particularly, complement the proteins of horsebean seed more adequately than do the proteins of vegetable origin. The exception is sunflower seed oil meal which in this experiment proved almost as effective as fish meal and casein, and was slightly superior to meat meal.

Experiment 2

It is recognized that in practical diets for growing chicks at least 20 per cent of the total protein should be derived from protein of animal origin (23). However, the specific amounts of animal protein required to supplement vegetable protein in poultry rations vary greatly depending upon the particular plant protein supplement used (14). Likewise, condensed fish solubles are reported to be a very rich source of factor or factors usually associated with animal protein and essential in chick nutrition (6, 7, 18).

The second experiment was undertaken to study primarily the relative complementary value of fish meal and meat meal fed alone or in combination at levels yielding 10 and 20 per cent of the total crude protein of the ration.

Condensed fish solubles at levels of 2 per cent and 4 per cent were also added to the basal ration. Because the horsebean meal had been lowered to approximately 25 per cent in the basal ration, soybean meal was used to make adjustments for the different amounts of animal protein supplements required to fix the desired protein ratios. Lots of twenty chicks were fed the experimental diets shown in Table 5 for a period of five weeks.

The results of this experiment are summarized in Table 6. An analysis of variance was carried out and the necessary difference for significance in mean final weights was found to be 33.6 grams. Based on this level of significance, the inclusion of fish meal protein at levels as low as 10 per cent of the total protein in the ration induced better growth than the horsebean meal fed alone or supplemented with meat meal at either of the two levels used in this experiment. Therefore, the improvement of the basal ration observed in lots 4 and 5 can be primarily attributed to the beneficial effects of fish meal. Further improvement was also observed when fish meal was incorporated into the basal ration at level of 20 per cent of the total protein. Condensed fish solubles when fed at levels of 2 per cent (about 3.5 per cent of the total protein) or 4 per cent of the total ration, gave results equal to

TABLE 6.—RELATIVE COMPLEMENTARY VALUE OF FISH MEAL, MEAT MEAL, AND CONDENSED FISH SOLUBLES TO THE HORSEBEAN SEED MEAL PROTEIN

Lot No.	Animal Protein Supplement	Per cent of the Total Protein	Final Weight at 6 Weeks[1]	Feed: Gain Ratio
			Grams	
1	Basal Ration	—	299.3	3.08
2	Meat Meal	10	297.5	3.01
3	Meat Meal	20	325.5	2.92
4	Meat Meal plus Fish Meal	5 5	324.7	2.89
5	Meat Meal plus Fish Meal	10 10	346.8	2.94
6	Fish Meal	10	338.8	2.82
7	Fish Meal	20	355.6	2.83
8	Condensed Fish Solubles	2% of the Ration	346.6	3.05
9	Condensed Fish Solubles	4% of the Ration	352.2	2.93

[1] Necessary difference for significance in final weight is 33.6 at the 0.05 level.

TABLE 7.—EFFECT OF SUPPLEMENTARY SYNTHETIC AMINO ACIDS[1], CHOLINE AND FOLIC ACID[2] IN THE BASAL HORSEBEAN SEED MEAL CHICK RATION

Lot No.	Supplement Added	Per cent of Dietary Requirement	Final Weight at 5 Weeks[3]	Feed: Gain Ratio	Feathering[3]	
					Growth Score	Achroma Score
			Grams			
1	Horsebean Seed Meal	—	142.5	3.69	3.1	2.6
2	Fish Meal	10% of Total Protein	238.8	2.32	2.0	1.6
3	Glycine (Gelatin)	50	157.4	3.45	2.7	2.8
4	dl-Tryptophane	25	149.0	3.52	2.7	2.6
5	dl-Methionine	50	246.1	2.69	0.6	1.2
6	Choline	100	187.2	3.04	3.7	2.6
7	dl-Methionine plus Choline	25 100	264.7	2.53	0.5	0.5
8	1.(+) Lysine	25	172.1	3.18	2.8	3.1
9	Folic Acid	100	146.6	3.39	2.9	2.3

[1] Supplied by Merck & Co. Ltd., Montreal, Canada.
[2] Supplied by Lederle Lab., Pearl River, N.Y., U.S.A.
[3] Necessary differences for significance in final weight and feathering are 33.4 and 0.7 respectively at the 0.05 level.

fish meal when the latter supplement contributed 2 per cent of the total protein. The inclusion in the basal horsebean ration of meat meal protein to a level of 20 per cent of the total protein failed to show a statistically significant beneficial effect. It is concluded from these observations that fish meal and condensed fish solubles were more suitable than meat meal as supplements to a practical horsebean seed meal ration for chicks.

Some difficulties were encountered in the scoring of feather growth and feather pigmentation. However, the high correlation coefficients obtained from data of the next experiment between body weight and feather growth score (−.872), body weight and achroma score (−.748) and feather growth and achroma scores (.898) indicate that rations which induced better growth of chicks also produced better feathering.

Experiment 3

Some legume seed proteins, e.g., soybean and pea proteins, are deficient in available sulphur-containing amino acids which are essential for the growth of chicks (3, 9). Consequently, significant improvements in the growth of chicks were observed when dl-methionine was added to practical chick starting rations containing large amounts of soybean and pea protein (8, 9, 11). On the other hand, definite biological relationships between choline, homocystine, cystine and methionine were demonstrated in the chick (1, 2, 13, 16). The addition of choline alone in certain instances enhanced the nutritive value of a soybean oil meal ration (11).

In the case of basal horsebean seed ration, it cannot be precluded that the lack of essential amino acids other than the sulphur containing groups may contribute to the poor biological response demonstrated thus far. Therefore, a variety of purified nutrients, viz., choline, folic acid, 1 (+) lysine, dl-methionine, glycine (gelatin) and dl-tryptophane were added to the basal horsebean ration in order to determine more specifically the major nutritive deficiencies of the horsebean meal. Fish meal was also fed as a comparative supplement.

The supplements were added to the basal horsebean ration at levels given in Table 7. Ten chicks per lot were fed the experimental rations for four weeks and the results of this experiment are summarized in Table 7.

An analysis of variance showed the necessary differences for significance to be 33.4 grams for body weight and 0.7 for feathering. Based on these levels of significance, supplementary fish meal, dl-methionine, choline, dl-methionine plus choline in the basal ration induced better growth than the raw horsebean meal alone. The abnormal feathering caused by the raw horsebean meal was corrected almost completely by supplementing the basal ration with dl-methionine alone, or dl-methionine plus choline. Some improvement of the feathering was also observed when fish meal was included in the horsebean ration, but this did not equal that produced by the synthetic supplements above. The amount of feed required to produce a unit of gain was greatly reduced when the horsebean meal was supplemented with fish meal, dl-methionine alone, or dl-methionine plus choline. No improvement of the horsebean seed meal was observed upon supplementation with glycine, dl-tryptophane, lysine, or folic acid. It is concluded that the primary deficiency of the horsebean meal protein lies in the low content of sulphur-containing amino acids.

SUMMARY

In a series of experiments with male Barred Plymouth Rock chicks, it has been demonstrated that horsebean seed meal with proper supplementation can serve as a basic source of vegetable protein in a chick starter ration. Without proper supplementation, horsebean meal is deficient in nutritional factors essential for optimum body growth and proper feathering in the chick.

When one-half of the crude protein supplied by 35 per cent horsebean meal to the basal ration was replaced by the following protein supplements, fish meal, sunflower seed meal, casein, meat meal, soybean meal and linseed oil meal, growth was significantly increased. In most instances, this was accompanied by better feather development. Fish meal and sunflower seed meal demonstrated superior supplementary value; casein supplemented the basal ration more adequately than soybean meal and linseed oil meal and meat meal proved better than linseed oil meal. A modified horsebean meal basal ration containing soybean meal was significantly improved by the addition of fish meal, but meat meal was without effect. On the basis of weight, condensed fish solubles and fish meal proved to have about equal value in correcting deficiencies of the basal meal ration.

By supplementing the basal horsebean ration with synthetic vitamins and amino acids, it was demonstrated that the primary deficiency of the horsebean seed protein lies in the low content of sulphur-containing amino acids. Supplementary dl-methionine alone was highly beneficial. When choline + dl-methionine were added to the basal horsebean ration, the deficiency was corrected to a very large measure as shown by improved body growth and restoration of normal feathering in the chicks.

ACKNOWLEDGMENT

The financial assistance of the Quebec Scientific Research Bureau which has made this study possible is gratefully acknowledged.

REFERENCES

1. Almquist, H. J., and R. C. Grau. Interrelation of methionine, choline, betaine and arsenocholine in the chick. J. Nutrition 27 : 265-269. 1944.
2. Almquist, H. J., and R. C. Grau. Further studies in cystine, methionine and choline in chick diets. J. Nutrition 29 : 219-222. 1945.
3. Almquist, H. J., E. Mecchi, F. H. Kratzer, and R. C. Grau. Soybean protein as a source of amino acids for the chick. J. Nutrition 24 : 385-393. 1942.
4. Bassot, G., La culture des fèves. Jour. d'Agr. Pra. 100 : 11-13. J. 1934.
5. Belzile, A. Notes sur la Gourgane (*Vicia faba* L.). La Bonne Terre. Avril 1942.
6. Berry E. P., C. W. Carrick, R. E. Roberts, and S. M. Hauge. Condensed fish press water and fish liver meal in chick rations. Poultry Science 24 : 270-276. 1945.
7. Bethke, R. M., D. C. Kennard, and V. D. Chamberlin. The relation of nutrition to production and hatchability of chicken eggs. 11. Poultry Science 25 : 579-583. 1946.
8. Bird, H. R., and J. P. Mattingly. Addition of dl-methionine to starting and growing rations. Poultry Science 24 : 29-33. 1945.
9. Bolin, D. W., C. F. Petersen, C. E. Lampman, and O. E. Stamberg. Chick growth response resulting from methionine additions to various protein supplements with pea protein. Poultry Science 25 : 157-161. 1946.
10. Briggs, G. M., and R. J. Lillie. Folic acid in the prevention of abnormal feather pigmentation of chick fed purified diets. Fed. Proc. 5 : 124. 1946.
11. Clandinin, D. R., W. W. Cravens, J. G. Halpin, and E. B. Hart. Supplementary value of methionine, cystine and choline in a practical soybean oil meal starter ration. Poultry Science 26 : 509-516. 1947.
12. Fritz, J. C., J. H. Hooper, J. L. Halpin, and H. P. Moore. Failure of feather pigmentation in Bronze poults due to lysine deficiency. J. Nutrition 31 : 387-396. 1946.
13. Grau, C. R., and H. J. Almquist. The utilization of the sulphur amino acids by the chick. J. Nutrition 26 : 631-641. 1943.
14. Heuser, G. F., L. C. Norris, and J. McGinnis. Vegetable protein concentrates fed alone and in combination with soybean oil meal and fish meal as the chief supplementary protein in chick starting rations. Poultry Science 25 : 130-136. 1946.
15. Hill, D. C. Protein in poultry nutrition. Sci. Agr. 24 : 551-590. 1944.
16. Klose, A. A., and H. J. Almquist. Methionine in the diet of the chick. J. Biol. Chem. 138 : 467-469. 1941.
17. Kratzer, F. H. The treatment of linseed meal to improve its feeding value for chicks. Poultry Science 25 : 542-543. 1946.
18. Lassen, Sven, and E. K. Bacon. The use of condensed fish solubles in poultry nutrition. Poultry Science 25 : 486-491. 1946.
19. Lillie, R. J., and G. M. Briggs. Folic acid requirements of New Hampshire chicks receiving synthetic diets. Poultry Science 26 : 295-298. 1947.
20. McKee, R. Horse beans. U.S.D.A. Farmers' Bull. 959. 1918.
21. Paquette R. Etude comparée de la digestibilité, in vitro, des protides précipitées de la gourgane, de la caséine, et de l'alpha-protéine de soya. Thèse présentée à l'Université de Montréal. Juin 1940.
22. Robertson, E. I., L. J. Daniel, F. A. Farmer, L. C. Norris, and G. F. Heuser. The folic acid requirement of chick for growth, feathering and hemaglobin formation. Proc. Soc. Exp. Biol. and Med. 62 : 97. 1946.
23. Titus, H. W. The scientific feeding of chickens, p. 56. The Interstate, Danville, Ill. 1941.
24. Wilgus, H. S., Jr., L. C. Norris, and G. F. Heuser. Relative protein efficiency and relative vitamin G content of common protein supplements used in poultry rations. J. Agr. Res. 51 : 383-399. 1935.
25. Woodmen, J. E., and R. E. Evans. The composition and nutritive value, when fed to ruminants, of pea-pod meal and broad bean-pod meal. J. Sci. Agr. 30 : 198-199. 1940.
26. Zagami, V. The food value of *Vicia faba* L. Chem. Abst. 28 : 3764. 1934.

BORON IN RELATION TO THE CULTURE OF THE PEACH TREE[1]

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Although the literature covering the role of boron in the growth of agricultural plants is extremely extensive, little has been found describing the use of this element in connection with peach trees when grown under field conditions. It is the purpose of this paper to describe boron deficiency and excess symptoms on peach and to relate these to the results of chemical analyses of tree tissues.

McLarty (5) reported a die-back on peach as a symptom of boron deficiency, but gave no detailed description. Davidson (1) stated that boron deficiency rarely occurs in peach orchards but that it has been found in commercial orchards in the northwestern United States. The affected trees were characterized by their leaves, which were small, thick, misshapen, and brittle.

Symptoms of boron deficiency on peach when grown in sand culture have been described by Weinberger and Cullinan (8). They found that peach trees not supplied with boron were rapidly and severely affected with disorders. Soon after a minus boron treatment was started, in one of their experiments, a dark green water-soaked spot appeared on every growing tip about one inch back from the end and exuded gum. Gradually this spot enlarged, became brown and necrotic, and girdled the growing point. The leaves beyond the affected area wilted and died and later the tip slowly died back for some distance. Numerous lateral buds below the dead tissue started growth, but these also were similarly affected after developing a few small narrow leaves. Older leaves developed small, irregularly shaped, necrotic areas, which later dropped out leaving a perforated leaf. Most of the leaves were somewhat chlorotic, and defoliation, which occurred early, proceeded from the tip toward the base and included most injured leaves. The bark became brown and rough, with many small cork-like growths. The root system was very poorly developed, and consisted chiefly of fibrous roots.

The symptoms caused by an excess of boron on peach have been described by various investigators. Haas (3), when using a culture solution containing 2 p.p.m. boron, found that the leaves burned severely along the entire margins, became wrinkled, and later splitting occurred as the drying out of the margins increased. In both experimental cultures and in the field, Eaton (2) observed boron injury as a tendency for the bark of twigs above some of the leaf axils to turn brown and split open, either with or without the extrusion of gum. Often the bark injury encircled the twig and caused death of the tissues above. When injury was sufficiently severe, the leaf tissues died irregularly along a narrow margin with an accompanying or preceding cupping of the leaf, and the breaking of the restricted margins gave the affected parts a ragged appearance. Weber (7) studied

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FIGURE 1. Peach tree showing moderate die-back in the spring on twigs of the previous year's growth due to boron deficiency.

FIGURE 2. Peach tree showing extreme condition of die-back. Most of the limbs and branches have died.

FIGURE 3. Tufted appearance of twigs on a peach tree as a result of a deficiency of boron.

the histological characteristics of the peach when grown in toxic concentrations of boron. He described in detail abnormalities found in peach stems when trees were grown in a culture solution containing 6 p.p.m. of boron and reached the conclusion that such abnormalities were in general similar to those which could be attributed to other causes.

SYMPTOMS OF BORON DEFICIENCY

As the symptoms of boron deficiency as encountered under field conditions in the Okanagan Valley in British Columbia do not correspond to those reported by investigators using sand cultures, the details are presented for comparison. The outstanding characteristic is the dying-back in the spring of twigs and branches on trees which had grown normally the previous season. There is no preliminary warning of the impending attack, for, during the preceding dormant period, the development of both leaf and flower buds corresponds with those on unaffected portions of the tree. No necrotic or atrophied tissues can be found in bud, spur or stem, and no gumming is in evidence. The earliest symptom is failure of both leaf and flower buds to "break" normally when growth starts in the spring. They remain alive until full blossom time, when the majority of them slowly turn brown and die. The stem tissues may remain normal in appearance for as long as from two to three weeks after the buds have died.

Wide variations occur in the severity of attack. The condition most frequently encountered is a dying-back of the previous season's terminal growth over the whole or on one portion of a tree (Figure 1). An extreme condition, but one which has frequently been observed, is illustrated in Figure 2—no or almost no buds "break" on an entire tree. The least recognizable symptom is the failure of the lateral buds to develop on a single twig of the previous season's terminal growth. Most susceptible to attack are the lateral buds on shoots that made rapid growth the previous season, and here the flower buds may succumb while the leaf buds survive. When the lateral buds on a twig are killed, and not the terminal bud, the subsequent growth gives to that twig a tufted appearance (Figure 3). Affected flower buds rarely develop their flowers, but affected leaf buds may survive and send out a retarded shoot growth. Occasionally this shoot may wither and die, but usually it lives and produces a healthy growth during the season. However, the first leaves that develop may be small, narrow, and with edges rolled inward. Wherever affected leaf buds survive, the stem tissues also remain alive and that portion of the tree recovers. When both the flower and leaf buds are killed the adjacent stem tissue usually dies, but sometimes adventitious buds develop and the twig survives.

Boron deficiency die-back has some symptoms in common with those caused by winter injury and it is frequently difficult to differentiate between them. The outstanding difference which has been observed is that with winter killing there is always a death of tissue, either in the stem, spur or blossom, which takes place shortly after their exposure to the killing temperature, whereas, with boron deficiency, there is no evident injury until after growth has started in the spring.

SYMPTOMS OF BORON EXCESS

Boron excess symptoms which have been observed in the field have usually appeared in the summer following a fall or spring in which an excessive application of boric acid was made. In severe cases, the tips of the current season's branches wither and die-back (Figure 4), cankers develop along the stems, and much gumming is in evidence (Figure 6). With less severe injury, small necrotic areas develop in the leaves along the midrib and small cankers develop on the underside of the midrib and in the petiole (Figure 5). The necrotic areas drop out after from 10 to 15 days, leaving perforations along the midrib. The symptoms are frequently associated with a brittleness of the leaves and a partial defoliation. Fruits on trees showing boron toxicity symptoms are malformed and kernal development is poor (Figure 7). Only in a few orchards have trees been killed outright and most trees exhibit these symptoms for just the one year immediately after an excessive application of boric acid. Under irrigation, the trees usually return to normal growth in the following season. Leaf symptoms, similar to those described, have been induced on 2-year-old peach trees in the first season that they were grown in sand culture out-of-doors when the nutrient solution contained 5 p.p.m. boron.

CHEMICAL ANALYSIS

Samples of twigs and leaves were collected over a period of two years from reputedly healthy trees and also from trees showing either boron deficiency or boron toxicity symptoms. The samples were dried, ground and analysed for total boron by the turmeric colorimetric method which has been described in detail by Naftel (6) and Haas (4). The results of these analyses are summarized in Figure 8, where the heavy horizontal lines represent the range of boron concentration found in tissues of a given category and the numeral above the line is the number of samples analysed in this category.

FIG. 8.—THE RANGE OF BORON CONTENT OF PEACH TWIGS AND LEAVES. (NUMERALS ABOVE HEAVY LINES INDICATE THE NUMBER OF SAMPLES ANALYSED IN EACH GROUP OF TWIGS OR LEAVES)

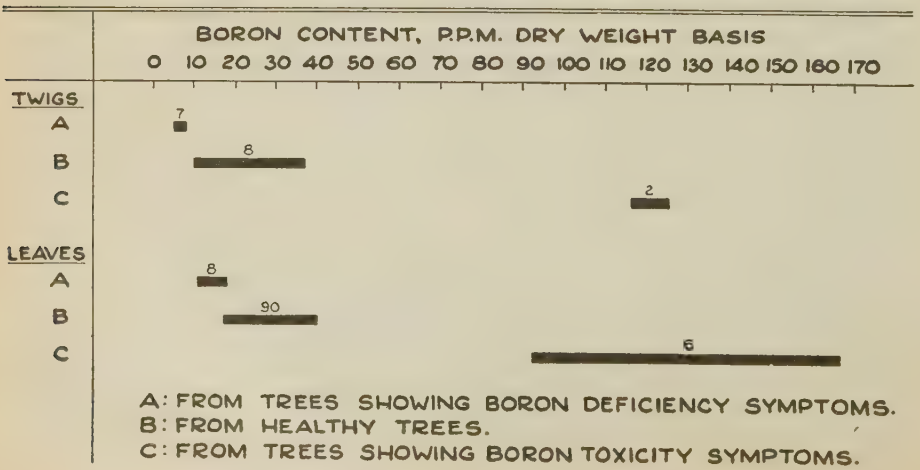

FIGURE 4. Twigs of a peach tree showing die-back in the summer on the current year's growth due to boron toxicity. (Compare with Figure 1).

FIGURE 5. Leaves of a peach tree showing injury due to boron toxicity. Note small necrotic areas along the midrib and cankers on the underside of the midrib. Some of the necrotic spots have dropped out.

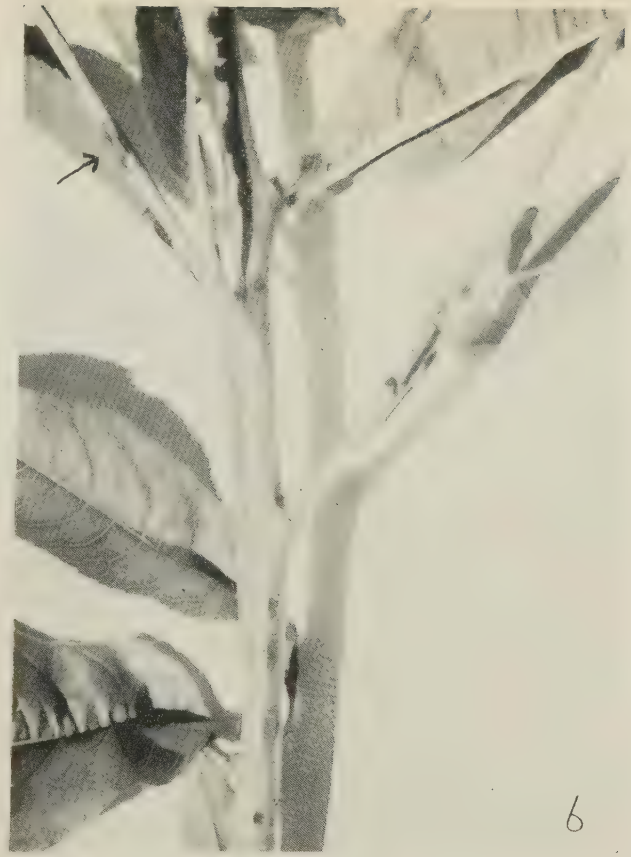

FIGURE 6. Example of severe boron toxicity on peach twigs; cankers are present along the stem and gumming *(arrow)* is in evidence.

FIGURE 7. Boron toxicity in fruit. The fruits are malformed and kernel development is poor.

SUMMARY

1. The outstanding characteristic of boron deficiency on peach is the dying-back in the spring of twigs and branches on trees which grew normally the previous season.

2. The symptoms of boron toxicity that are most readily recognized are small necrotic areas along the midrib of the leaf and small cankers on the underside of the midrib.

3. The results of the chemical analyses indicate that, if the boron content on a dry weight basis of the leaves is less than 20 p.p.m., or that of the twigs is less than 10 p.p.m., boron deficiency symptoms are very likely to be present. If the boron content of leaves is greater than 90 p.p.m., and that of twigs is greater than 110 p.p.m., boron toxicity symptoms will most probably be apparent. Normal leaves and twigs contain 17 to 40 p.p.m. and 10 to 37 p.p.m., respectively.

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REFERENCES

1. Davidson, O. W. Hunger signs in crops. A symposium. Judd and Detweiler. Washington, D.C. 1940.
2. Eaton, F. M. Boron in soil and irrigation waters and its effects on plants. U.S. Dept. Agr. Tech. Bull. 448. 1935.
3. Haas, A. R. C. Toxic effect of boron on fruit trees. Bot. Gaz. 88 : 113-131. 1929.
4. Haas, A. R. C. The turmeric determination of water soluble boron of citrus orchards in California. Soil Science 58 : 123-137. 1944.
5. McLarty, H. R. British Columbia uses boron for fruit. Better Crops With Plant Foods 24 : 8-11, 37-38. 1940.
6. Naftel, J. A. Colorimetric microdetermination of boron. Ind. Eng. Chem. Anal. Ed. 11 : 407-409. 1939.
7. Weber, I. E. Histological characteristics of plants grown in toxic concentrations of boron. J. Agric. Res. 50 : 189-194. 1935.
8. Weinberger, J. H., and F. P. Cullinan. Symptoms of some mineral deficiencies in one-year Elberta peach trees. Proc. Amer. Soc. Hort. Sci. 34 : 249-254. 1936.

A MECHANICAL SHAKING DEVICE[1]

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The recent advent into North American commerce of several kinds of seed-treating machines, for applying fungicides in dry or wet form to the seed, has given rise to a need for a laboratory seed-treater which gives standard "mixes" on the basis of which the efficiency of commercial machines could be determined. Existing laboratory seed-treating devices have limited use, being designed for either dusts or for fluids. In some cases, when both can be applied by the same machine, there are various drawbacks limiting the machine's use. The device described here (Figure 1) has the advantage of being able to prepare as many as six one-pound mixes at a time, so that a considerable quantity of seed can be handled. Dry or wet disinfectants may be applied simultaneously and an exact count may be obtained of the number of shakes given the mixtures.

The present machine was designed and built in the instrument shop of the Dominion Laboratory of Cereal Breeding, Winnipeg, for the purpose of mixing seed and fungicide. From observations made over a period of several years by J. E. Machacek, of the Dominion Laboratory of Plant Pathology, Winnipeg, it appeared that the best mixtures were obtained by putting about one pound of seed in a half-gallon Mason jar and then holding the jar at about 45°, moving it rapidly with a rotary motion of the hand through approximately a six-inch circle. This gave the seed a sliding, tumbling motion, and left no unmixed "pockets" in the jar. This motion imparted by hand shaking is duplicated in the machine described below but without the variations resulting from manual operation.

This machine consists of three essential parts: a rack which holds the Mason jars at an angle of 45° in semi-cylindrical troughs lined with sponge rubber; a motor-driven mechanism which moves the rack 300 revolutions per minute through a three-inch circle, and a resettable counter attached to one of the crankshafts which drive the rack. All these components are mounted on a rigid, angle-iron frame.

The moving rack is built of 22-gauge sheet iron welded to a $\frac{5}{8}$-inch steel tubing framework. The troughs for the Mason jars are formed in the sheet iron rack and the sponge rubber cushion is fixed in place with rubber-base adhesive. The jars are held firmly in place by means of straps of rubberized webbing equipped with adjustable buckles. Where a uniform size of jar is always used, a sponge-lined steel strap with luggage clasps attached will allow faster manipulation. The whole rack is attached to two crankshafts, to one by two rigid tubular legs with brass bearings, and to the other by two hinged legs with brass bearings. This arrangement, of rigid and hinged legs, reduces the stresses arising from wear or irregularity in assembly. Both crankshafts run in bronze bearings and are driven by bicycle chains and sprockets. With this dual driving arrangement the

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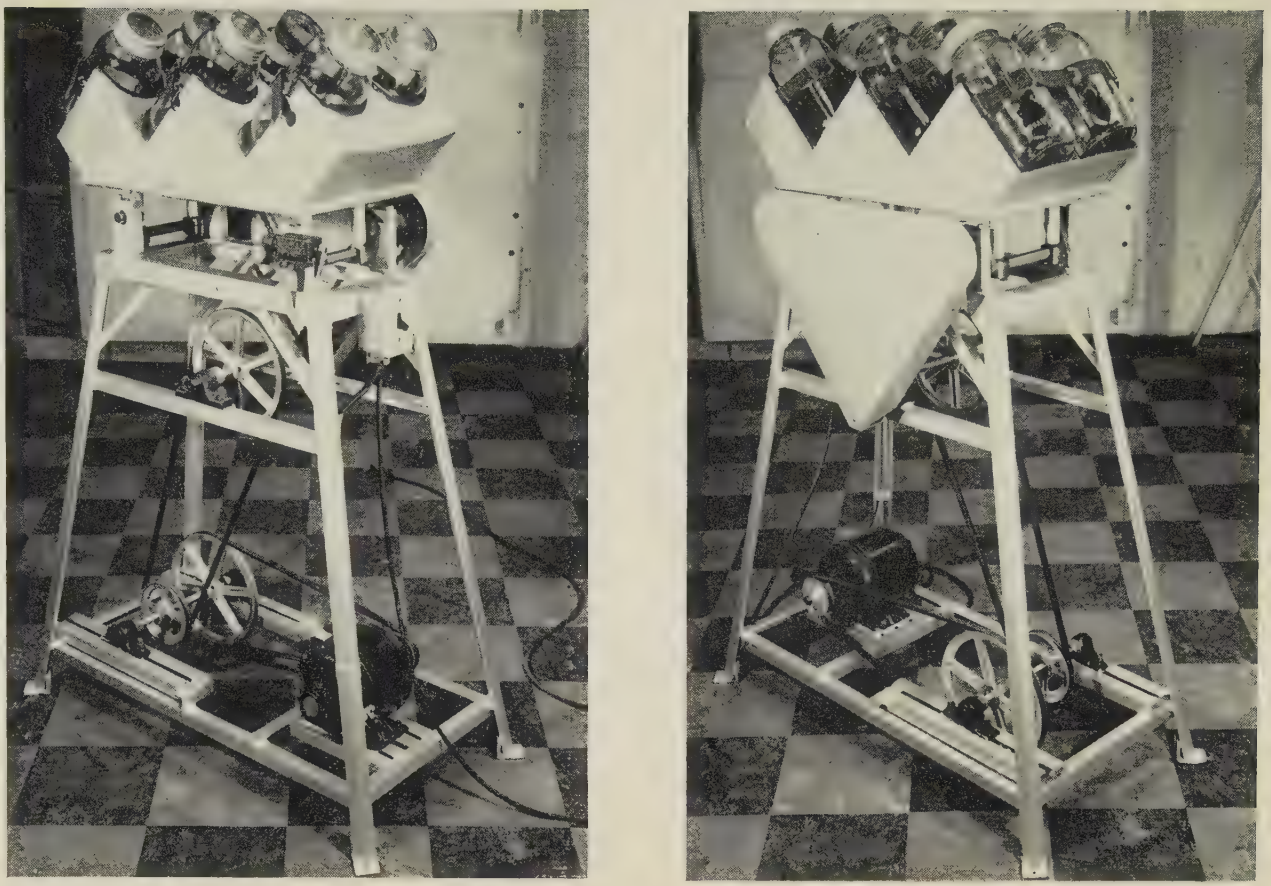

(a) (b)

FIGURE 1. Views of mechanical shaking device.

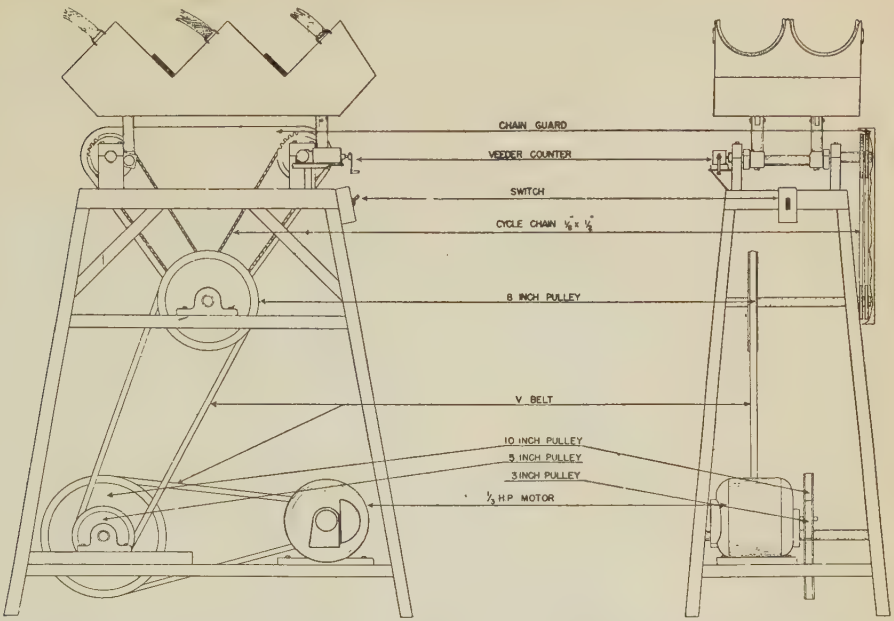

FIGURE 2. Driving arrangement for mechanical shaking device (Scale 13/16 in = 1 foot).

rack will move as required; but if only one drive chain is used, the undriven crankshaft will merely rock to and fro, leaving that end of the rack comparatively unshaken.

The drive for both chains is taken from the second of two countershafts used to reduce the motor speed of 1725 r.p.m. to the 300 r.p.m. required for satisfactory operation. Power is transmitted from the one-third horsepower motor through the two countershafts by V-belts and pulleys. The whole drive arrangement is shown in Figure 2.

A counter with a manual reset which is used to determine the number of shakes each lot of samples receives is located on the main framework below the jar rack. A switch for starting and stopping the motor is also attached to the framework near the counter.

The main framework is fabricated from 1 in. × 1 in. × $\frac{1}{8}$ in. angle iron, except the top members which are $1\frac{1}{2}$ in. × $1\frac{1}{2}$ in. × 3/16 in. All joints are welded together.

Our observations show that this machine may satisfactorily be used for other purposes such as mixing inoculum with seed, preparing emulsions, mixing paints, and the like. Where a large number of small samples are to be shaken, interchangeable racks may be used.

While in operation the machine should be bolted to the floor; or if used in a temporary location, the legs should be bolted to planks weighed down with heavy objects such as boxes of sand. Without this anchoring, the machine tends to vibrate to a considerable degree.

A RAPID METHOD OF ESTIMATING SOIL IN RUN-OFF SUSPENSIONS[1]

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INTRODUCTION

In the measurement of soil and water losses resulting from erosion on experimental plots of the Division of Field Husbandry, Central Experimental Farm, Ottawa, Ontario, the run-off is collected in catchment tanks located at the lower end of the plots. Some preliminary results from this experiment have been reported (1). Samples of the soil-water suspensions from the tanks are brought to the laboratory for determination of the amounts of soil and water. The procedure has been to evaporate weighed aliquots of the suspensions to dryness and to calculate the per cent soil present from the weight of the dried residue. Although this procedure, which will be referred to as the "evaporation method", has proved satisfactory in most respects it requires laboratory space and considerable equipment.

Since in some instances erosion experiments may be located in areas where laboratory facilities are not conveniently available, it was decided to investigate the possibility of estimating the amount of soil in the suspensions from the difference in weight between a given volume of water and an equal volume of the suspension. The amount of soil in a suspension may be calculated from the equation

$$P = \frac{100S(X-Y)}{X(S-1)} \qquad \text{Equation 1}$$

where P is the per cent soil in the suspension, S is the specific gravity of the soil, and X and Y are the weights of equal volumes of the suspension and water respectively at the same temperature. It is evident that such a method should be feasible providing the specific gravity of the soil in the various suspensions is relatively constant.

EXPERIMENTAL

(a) Estimation of Specific Gravity of Soil in Suspension

The soil of the experimental area has been mapped as Rideau clay (2). It is described as a very heavy, moderately drained, stone-free soil, slightly to moderately acid in reaction, and is relatively low in organic matter.

Composite samples of the dried residues from the run-off suspensions collected in 1946, for each of four plots, provided a basis for establishing an estimate of the average specific gravity of the soil in the suspensions. The specific gravity of each of these four samples was determined by the method

[1] Joint contribution from the Division of Chemistry, Science Service and the Division of Field Husbandry, Soils and Agricultural Engineering, Experimental Farm Service. Scientific contribution No. 182, Division of Chemistry, Science Service.

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described by Lyon and Buckman (3) except that the air was removed from the soil-water mixtures in the pycnometers by placing them in a vacuum. The results, presented in Table 1, show that the mean specific gravity of the soil material was 2.657 and that the variation from the mean for the individual samples was very small.

TABLE 1.—SPECIFIC GRAVITY OF SOIL MATERIAL IN THE RUN-OFF FROM FOUR PLOTS IN 1946

Plot	Specific gravity
5	2.656
11	2.664
20	2.653
21	2.655
Mean.....	2.657

By using the value 2.66 for the specific gravity of the eroded material as an estimate of S in Equation 1, the per cent soil in the suspensions may be calculated without recourse to drying the samples. On this basis, a rapid method of estimating eroded material in run-off suspensions is proposed and will be referred to as the "specific gravity method".

(b) Description and Evaluation of the "Specific Gravity Method"

The procedure for the "specific gravity method" was as follows: A bottle of about 800 ml. capacity, with a ground glass stopper through which a hollow glass tube passed, was constructed out of an ordinary Erlenmeyer flask and a ground glass joint. The glass tube through the stopper was 4 mm. in diameter and extended from the bottom of the stopper to about 2 cm. above the top. The weight and volume capacity of the bottle were determined accurately. The weight of suspension required to fill the bottle was determined and the temperature recorded. The weight of an equal volume of water was calculated from the known capacity of the bottle and the density of water at the temperature recorded. The per cent soil in the suspension was then calculated from Equation 1.

Following the above procedure, the per cent soil in each of 41 suspensions collected from the experimental plots over a period of two years was determined in duplicate. The means of these duplicate determinations, along with the corresponding values obtained with the "evaporation method", are presented in Table 2. The standard error for each method, and the standard error based on the differences between means of duplicate determinations by each method, are included. The two methods gave similar results. The standard errors of $\pm$ 0.026 for the "specific gravity method" and $\pm$ 0.043 for the "evaporation method" were small. The standard error based on the differences between means of duplicate determinations by each method was $\pm$ 0.077. Although this latter error was of a greater magnitude than can be accounted for by the errors within methods, it was not appreciable.

TABLE 2.—PER CENT SOIL IN RUN-OFF SUSPENSIONS BY THE EVAPORATION AND SPECIFIC GRAVITY METHODS

(Means of duplicate determinations)

Plot No.	Date of rain	Soil in the suspensions		Plot No.	Date of rain	Soil in the suspensions	
		Evaporation method	Specific gravity method			Evaporation method	Specific gravity method
		%	%			%	%
1	27–8–49	1.80	1.80	11	24–7–48	4.34	4.49
2	7–7–48	2.62	2.59	11	21–6–49	1.72	1.65
2	25–6–49	0.84	0.89	11	25–6–49	6.62	6.63
2	30–7–49	0.61	0.62	11	27–8–49	4.69	4.75
5	24–7–48	2.49	2.40	11	30–8–49	2.52	2.56
5	25–7–49	2.40	2.36	12	30–7–49	2.45	2.39
5	29–7–49	1.78	1.77	13	7–7–48	6.15	6.30
5	26–8–49	4.28	4.42	13	25–6–49	2.32	2.12
5	13–9–49	2.44	2.47	13	29–7–49	0.91	0.88
6	7–7–48	5.47	5.57	14	30–8–49	4.26	4.31
6	24–7–48	1.53	1.43	18	30–8–49	0.68	0.69
6	21–6–49	1.86	1.71	19	30–7–49	0.69	0.71
6	25–6–49	3.37	3.36	19	30–8–49	1.03	0.91
6	29–7–49	2.24	2.23	20	7–7–48	2.45	2.54
6	29–8–49	4.43	4.49	20	24–7–48	1.05	0.96
6	13–9–49	2.37	2.49	21	7–7–48	2.64	2.60
10	7–7–48	5.55	5.56	21	21–6–49	1.24	1.16
10	25–6–49	3.32	3.30	21	25–6–49	2.25	2.29
10	30–7–49	3.00	3.02	21	14–9–49	1.95	1.97
10	26–8–49	5.30	5.35				
10	14–9–49	3.95	3.97		Mean	2.87	2.87
11	7–7–48	6.06	6.04				

Standard error of a single determination with Evaporation Method ± 0.043.
Standard error of a single determination with Specific Gravity Method ± 0.026.
Standard error based on the differences between means of duplicate determinations by each method ± 0.077.

DISCUSSION

The "specific gravity method" has given essentially the same results as the "evaporation method" under the conditions of the erosion experiment at Ottawa. The specific gravity of the soil in suspensions from experiments located on other soils might vary somewhat from that found in this investigation but it may be readily determined. On soils relatively high in organic matter the specific gravity of the soil in the different suspensions might vary to a greater extent than was encountered in this investigation.

In many erosion experiments a reasonable estimate of the amount of soil lost by erosion is all that is required. In such cases the specific gravity of the soil could be assumed to be 2.65, the average for mineral soils (3), and the "specific gravity method" used to estimate the per cent soil in the suspensions. In this connection it should be noted that a difference of 0.1 between the actual specific gravity of the soil in the suspension and that assumed for calculating would cause an error of only about 2.5 per cent in the estimation of the amount of soil present.

SUMMARY

A rapid method for the determination of the amount of soil in the soil-water run-off suspensions from plots in an erosion experiment has been proposed. The method is based on the difference in weight between equal

volumes of water and the suspension at the same temperature. It does not require laboratory space, and the equipment needed is an ordinary beam balance accurate to 0.1 grams, a specially constructed bottle, and a thermometer.

The method has been compared with the "evaporation method" and has been found to give satisfactory results.

REFERENCES

1. Progress Report, 1936-1948, Division of Field Husbandry, Soils and Agricultural Engineering, Central Experimental Farm, Ottawa.
2. Hills, G. A., and N. R. Richards. Soil Survey of Carleton County, Province of Ontario. Report No. 7 of the Ontario Soil Survey. March 1944.
3. Lyon, T. L., and H. O. Buckman. The nature and properties of soils. The MacMillan Co., New York. 1937.

PACKAGE MEASLES OF TULIPS[1]

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Large losses of tulip bloom were sustained by two greenhouse operators on Vancouver Island through the extensive development of spots on the foliage and petals after the bloom was wrapped in oil paper for shipment to market, a condition known locally as "package measles". The spots appear as small water-soaked areas, less than 2 mm. in diameter, within twenty-four hours after the bloom is wrapped. These spots later become slightly sunken.

A close examination of the growing plants at the time the bloom was being cut failed to reveal any spots or other abnormalities in the foliage, except a general but slight etiolated condition, probably due to a long period of dull weather preceding the appearance of the bloom. The investigation revealed also that it was the practice of the operators to place the exposed stem bases of the packages of wrapped tulips in water for as long as twenty-four hours before placing them in cartons for shipment. Consequently, water condensation within the wax paper packages was suspected as being the cause of "package measles".

EXPERIMENTAL

An experiment was undertaken to ascertain whether or not moisture condensation within the packages was a contributing factor in the development of "package measles". The exposed stem bases of ten packages, each of one dozen blooms, were placed in water for twenty-four hours immediately after they were cut and wrapped. Ten dozen unwrapped blooms were placed in water for twenty-four hours and then wrapped. Forty-eight hours after both lots of bloom had been cut, the packages were opened. The blooms within all the packages bore the typical symptoms of "package measles", but, without an exception, the spotting was less extensive and less conspicuous on the blooms that had been placed in water twenty-four hours before they were wrapped. Moisture condensation within the packages appeared to favour the development of the disease.

Another experiment was designed to ascertain whether or not the disease was confined to the original two greenhouses whose operators had reported large losses. Ten dozen tulips from each of the two houses were packaged immediately after being cut and the exposed stem bases were placed in water for twenty-four hours. A like number from two houses whose operators had not reported losses were handled in the same manner. Twenty-four hours after wrapping, typical symptoms of the disease were found on the bloom in the packages from the original houses, but none on the bloom from the second pair of houses, although the environment in both pairs of houses seemed to be identical. It was evident, therefore, that moisture was not directly responsible for the trouble.

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The discovery of some plant debris, covered with conidiophores of a *Botrytis* sp. in the original houses, served as a clue to the cause. The operators of these two greenhouses had allowed considerable plant debris, chiefly tulip foliage, to accumulate under the benches, and considerable portions of the debris were covered with a fur of conidiophores of the *Botrytis* sp. Spore measurements indicated that the fungus was a form of *B. cinerea* rather than of *B. Tulipae*. A spore suspension was prepared from the spore-bearing parts of this debris by shaking the parts in water. This spore suspension was sprayed upon the tulips in a house the blooms from which had not shown the disease. Ten dozen blooms were then cut, wrapped, and the stem bases placed in water for twenty-four hours. The typical symptoms of "package measles" developed within that time in all ten packages.

Characteristic spots of experimental and of natural "package measles" on the foliage were examined after clearing in lacto-phenol and staining, but in few cases could fungus mycelia be detected in the lesions that had developed within twenty-four hours at approximately 45° F. However, by maintaining such bloom for three or four days in a humid atmosphere, no difficulty was experienced in detecting mycelia and in isolating *B. cinerea* from the lesions. The spotting of foliage with little evidence of fungus penetration has been described by Wilson (1) in connection with his study of chocolate spot of broad bean, a disease also caused by a form of *Botrytis cinerea*.

An experiment was then undertaken with a view to developing a control measure through the prevention of the growth of the *Botrytis* spores on the foliage, for this growth appeared to be the direct cause of "package measles". The tulip plants in one of the original houses were divided into a number of lots and each was sprayed or dusted with a different fungicide, a dozen or more having been used. The bloom was then cut, wrapped, and placed in water, as in the first experiments. Ten packages from each treatment were taken. The opening of the packages after twenty-four hours revealed that the majority of the sprays and dusts left undesirable residues on the foliage and petals, or in themselves caused injury, particularly to the petals. Two thiram sprays, one of Dutch and the other of American manufacture, at 0.5 per cent concentrations, caused foliage and petal injury and failed to prevent the development of "package measles". Ferbam (Fermate) and zineb (Parzate), at the same concentrations, left conspicuous, and therefore undesirable, residues on the foliage, although both were reasonably effective in preventing the development of "package measles". Folosan dust (20 per cent pentachloronitrobenzene) prevented the development of the characteristic symptoms, but the dust on the foliage was sufficiently conspicuous to mar the appearance of the bloom. Nabam (Dithane), as a 0.5 per cent spray, was the most promising. When the ten packages receiving this treatment were opened twenty-four hours after the sprayed blooms had been cut, wrapped, and placed in water, symptoms of "package measles" were not evident and little spray injury could be detected.

Inquiries made after the above-mentioned experiments were carried out revealed that "package measles" has been of not infrequent occurrence in other greenhouses and in other years. The principal source of infection appears to be tulip debris left under greenhouse benches. On this debris,

abundant inoculum of *Botrytis cinerea* is produced during periods of humid dull weather. It is during and for a time following such weather that the disease is prevalent on packaged blooms. The practice of thorough greenhouse sanitation would appear to be an adequate preventive measure.

SUMMARY

Large losses were sustained by two greenhouse operators through "package measles" of tulip bloom, a disease characterized by an extensive spotting of the foliage and petals and which develops only after the bloom is cut, and wrapped in wax paper for market. Moisture within the packages was found to be a contributing factor, but the primary cause was traced to contamination of the bloom prior to cutting with spores of a form of *Botrytis cinerea* that originated on plant debris beneath the greenhouse benches during periods of dull, humid weather. Non-contaminated plants when sprayed with a spore suspension and immediately cut and wrapped developed typical symptoms within twenty-four hours at 45° F. Symptom development on the bloom in the packages was prevented by spraying the plants prior to bloom cutting with a 0.5 per cent solution of nabam.

REFERENCE

1. Wilson, A. R. The chocolate spot disease of beans (*Vicia faba* L.) caused by *Botrytis cinerea* Pers. Ann. Bot. 24 : 258-288. 1937.

THE LOGICAL PRESENTATION OF IDEAS*

Many of the mistakes in scientific papers involve errors in logic. Their avoidance depends chiefly upon a thorough understanding and careful analysis of the ideas that are presented. The following rules apply to some of the most obvious, and yet commonest, mistakes of this type.

1. *Requisites of a good hypothesis.* Is it new? Is it worthy of consideration? (*a*) Do not present as new a hypothesis that really is old. But defective hypotheses of others may be improved, and presented as modified hypotheses. (*b*) The hypothesis should give promise of explaining facts or relations that have not hitherto been explained. (*c*) The hypothesis should be consistent with itself and with well established facts and principles. (*d*) Do not stress one hypothesis when another, or others, would fit the facts equally well. Employ the method of multiple working hypotheses. (*e*) Do not give a complex hypothesis when a simpler one would fit the facts equally well. (*f*) It is rarely useful to propose a hypothesis that cannot be tested or verified. (*g*) The hypothesis should aid the prediction of new facts or relations.

2. *Illusions.* (*a*) Be careful not to draw conclusions from data involving errors of observation, errors in arithmetic, compensating errors, systematic and personal errors. (*b*) Do not use mathematical formulae without clearly understanding their derivation and all the assumptions involved. (*c*) Be cautious in comparing conclusions based upon experiments in which the influential conditions have been improperly controlled, and therefore, not duplicated. (*d*) Guard against drawing an illogical conclusion. (*e*) Avoid confusing facts with opinions or inferences, not only in the investigation itself but also in preparing results for publication.

3. *Too broad generalization.* (*a*) Do not draw a conclusion from too few data, nor too broad a conclusion from a limited series of data. (*b*) Be careful in drawing conclusions that are based on extrapolated curves. (*c*) Guard against failing to qualify a conclusion, so as to show the limits within which it applies, or the variation which is to be expected. (*d*) When you indulge in speculation, be sure that you, and your reader, know that it is speculation.

4. *False relation between cause and effect.* (*a*) Do not infer merely because one thing has followed another that it is the effect of the other. (*b*) Do not argue that causes are the same because identical or indistinguishable effects have been observed. A certain phenomenon may have one cause in one case and another cause in a second case. (*c*) Be careful in making inferences by analogy. If two cases resemble each other in certain particulars, it is not safe to infer resemblance in another particular that has been observed in only one of them. (*d*) If two processes have the same mathematical expression (or yield the same sort of graph when plotted), it does not necessarily follow that the processes themselves are essentially alike.

5. *Prejudice.* (*a*) An attitude of intellectual honesty and devotion to truth is the foundation of scientific work. (*b*) Guard against prejudice; do not be influenced by preconceived opinions. (*c*) Do not decline to admit evidence because it necessitates an unwelcome conclusion. If a

* Reprinted from "Preparation of Scientific and Technical Papers" by Trelease and Yule. 1937.

conclusion is unwelcome, it is a sign something is wrong with one's mental attitude. (*d*) Biting, caustic comments are almost sure to be regretted later, and they almost invariably weaken the effect of one's arguments.

6. *Ambiguity of terms.* (*a*) Guard against misunderstandings of language. (*b*) Define terms as clearly and precisely as possible. Do not use technical terms, especially in a field not strictly your own, unless you are certain of their precise meaning, or unless their use has been checked by a specialist in the field. (*c*) Do not use a term in one sense in one part of your reasoning and in another sense in another part. (*d*) Do not mistake a general for a specific use of a term. (*e*) Be very critical of statements containing the words "cause", "determine", "control," "influence", "result", "effect". Distinguish carefully between such words as "force", "agency", "process".

7. *Missing the point.* (*a*) Do not ignore the question, evade the issue, or argue beside the point. Define clearly the points at issue. Try to determine the crucial point that will really decide the discussion. (*b*) Guard against reasoning that may correctly prove something but not the thing which you think it proves.

8. *Begging the question.* (*a*) Do not base a conclusion on an unproved proposition. (*b*) Avoid arguing in a circle—drawing a conclusion that merely states the assumptions in other words. (*c*) Do not assume the truth of a proposition that is not proved and may be false. (*d*) Do not assume that a certain thing is true because a prominent authority has said it is true. (*e*) Do not assume that a proposition is untrue because you are able to disprove the arguments that have been used to support it; there may be other, valid arguments that make it true.

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1. Canada moves North. Richard Finnie. Revised edition. Toronto, The Macmillan company of Canada limited, 1948. 239 p. il.
2. Horace Plunkett; an Anglo-American Irishman. Margaret Digby. Oxford, Basil Blackwell, 1949. 314 p. il.
3. Democratic government in Canada. Robert MacGregor Dawson. Toronto, Copp Clark co. ltd., 1949. 188 p. il. bibliography: pp. 183-4.
4. Natural regions of the U.S.S.R. L. S. Berg. Translated from the Russian by Olga A. Titelbaum. Edited by John A. Morrison and C. C. Nikiforoff. New York, The Macmillan company, 1950. 436 p. figs. tabs. maps. bibliography: pp. 363-365.
5. Abridged decimal classification and relative index. Melvil Dewey. Edition 6. Lake Placid Club N.Y., Forest press inc., 1945. 343 p.
6. Mathematics dictionary. Revised and enlarged edition. Edited by Glenn James and Robert C. James. New York, Van Nostrand, 1949. 432 p. tabs.
7. Canada. Edited by George W. Brown. Berkeley, University of California press, 1950. 621 p. il. plates. tabs. Selected bibliography: pp. 591-608. (United nations series)
8. Science is a sacred cow. Anthony Standen. New York, Dutton, 1950. 221 p. (A readable book debunking the pretensions of scientists on behalf of science)

AGRICULTURAL CREDIT

9. Financing the farm business. I. W. Duggan and Ralph U. Battles. New York, Wiley, 1950. 354 p. tabs. References at end of chapters.

AGRICULTURAL EDUCATION

10. Teaching agriculture. Carsie Hammonds. New York, McGraw-Hill book company, inc., 1950. 353 p.

AGRICULTURE—ECONOMIC CONDITIONS

11. United States influences on the agriculture of Prince Edward county, Ontario . . . Richard Dix. (Economic geography, vol. 26, no. 3, July, 1950, pp. 179-182)
12. Farming in Alberta, Canada. R. E. English. Edmonton, Alberta department of agriculture, 1949. 40 p. il.

BACTERIOLOGY

13. The cytology and life-history of bacteria. K. A. Bisset. Edinburgh, E. & S. Livingstone, ltd., 1950. 136 p. figs. Bibliographies at end of each chapter.
14. Industrial microbiology. Samuel Cate Prescott and Cecil Gordon Dunn. Second edition. New York, McGraw-Hill book company, inc., 1949. 923 p. figs. tabs. References at end of each chapter.
15. Introduction to the bacteria. C. E. Clifton. New York, McGraw-Hill book company, inc., 1950. 528 p. figs. tabs. References at end of each chapter.

BEES

16. The honeybee; an introduction to her sense-physiology and behaviour. C. G. Butler. Oxford, Clarendon press, 1949. 139 p. References through the text.

BIOLOGY

17. Unresting cells. R. W. Gerard. New York, Harper, 1949. 439 p. il.
18. Amino acids and proteins. Cold Spring Harbor, L.I., N.Y., The Biological laboratory, 1950. 217 p. figs. tabs. References through the text. (Cold Spring Harbor symposia on quantitative biology. Vol. XIV)
19. Survey of biological progress, Vol. 1, 1949. Edited by George S. Avery, jr. New York, Academic press, inc., 1949. 396 p. References at end of each chapter.

BOTANY

20. An introduction to plant physiology. Otis F. Curtis and Daniel G. Clark. New York, McGraw-Hill book company, inc., 1950. 752 p. figs. tabs. References at end of each chapter.
21. Laboratory exercises: biology of plants. H. L. Dean. Dubuque, Iowa, Wm. C. Brown company, 1949. 265 p. (processed) figs.
22. National botanic gardens of South Africa. Report and accounts, 1949. Kirstenbosch, 1950. 20 p.
23. Three new species and one new form in Bromus. H. Keith Wagnon. (Leaflets of Western botany. vol. VI, no. 3, 1950, pp. 64-69)
24. Notes on some Chinese species of Aconitum with an enumeration of the Chinese species represented in the Edinburgh Herbarium. H. R. Fletcher and L. A. Lauener. plates. (Notes from the Royal botanic garden, Edinburgh, vol. XX, no. C, January, 1950, pp. 181-206)
25. La nomenclature et la synonymie des sous-espèces de Cyperus Papyrus L. Roland Tournay. (Société Royale de botanique de Belgique. Bulletin. Tome LXXXII, fasc. II, mars, 1950. pp. 345-352)
26. La terminologie des types en botanique systématique. Georges Troupin. (Société Royale de botanique de Belgique. Bulletin. Tome LXXXII, fasc. 1, octobre, 1949, pp. 57-65)
27. Plant ecology work book; laboratory, field and reference manual. J. T. Curtis. Minneapolis, Burgess publishing co., 1950. 39 p. (processed) (Selected references to the literature of plant ecology: pp. 34-39)
28. Monographie du gentre Arctium L. J. Arénes. figs. (Bruxelles. Ministère de l'agriculture. Jardin botanique de l'état. Bulletin, vol. XX, fascicule 1, 1950, pp. 67-156)
29. Topography of the laticiferous system in the genus Ficus. M. C. Vreede. (Buitenzorg. Jardin botanique. Annals, vol. 51, part 2, December, 1949, pp. 125-149)
30. The natural philosophy of plant form. Agnes Arber. Cambridge, University press, 1950. 247 p. figs. List of books and memoirs cited: p. 229.
31. Grundlagen des pflanzenlebens. Heinrich Walter. Stuttgart, Verlag Eugen Ulmer, 1950. 491 p. il. References at end of each chapter. (Einführung in die phytologie. Band I) Third edition.

BREWING INDUSTRY

32. Facts on the brewing industry in Canada. A manual outlining the development of the industry and its place in the Canadian economy. Ottawa, Dominion brewers association, 1948. 127 p. charts. tabs. bibliography: pp. 121-122.
33. Industrial evaluation of six varieties of barley grown in 1947. Madison, Wisconsin, 1949. 40 p. tabs. (Malt research institute. Publication no. VIII)
34. Wallerstein laboratories. Communications. New York. Vol. XIII, no. 41, June, 1950.

CHEMISTRY—BIOCHEMISTRY—CHEMIC TECHNOLOGY

35. Textbook of biochemistry. Benjamin Harrow. Fifth edition. Philadelphia, W. S. Saunders company, 1950. 609 p. figs. tabs. References at end of each chapter.
36. Outlines of biochemistry. Ross Aiken Gortner. Third edition, edited by Ross Aiken Gortner, jr. and Willis Alway Gortner. New York, 1949. 1078 p. Bibliographical footnotes.
37. Frontiers in colloid chemistry, Volume VIII. Editors, R. E. Burk and Oliver Grummitt. New York, Interscience publishers, inc., 1950. 157 p. figs. References at end of each chapter.
38. The chemistry of organic medicinal products. Glenn L. Jenkins and Walter H. Hartung. Third edition. New York, John Wiley & sons, inc., 1941. 745 p. tabs. References at end of each chapter.

CHEMISTRY—BIOCHEMISTRY—CHEMIC TECHNOLOGY—Continued

39. Phenomena, atoms and molecules; an attempt to interpret phenomena in terms of mechanisms or atomic and molecular interactions. Irving Langmuir. New York, Philosophical library, 1950. 436 p. figs. tabs. Bibliography: List of papers published by Irving Langmuir, arranged according to subject matter: pp. 401-410.
40. Annotated bibliography of subtilin: Assay, microbiological production, purification and chemistry, biological activity, and related compounds, J. C. Lewis. Albany, Cal., 1950. 13 p. (processed) (U.S. Department of agriculture. Bureau of agricultural and industrial chemistry. Western regional research laboratory. AIC-168)
41. Production of riboflavin (vitamin B_2) with Ashbya gossypii. Thomas G. Pridham and others. Peoria, Illinois, Northern regional research laboratory, 1950. 12 p. figs. tabs. (processed) (U.S. Department of agriculture. Bureau of agricultural and industrial chemistry. AIC-271)
42. Production of a friable meal from feathers, Charles H. Binkley and Otto R. Vasak. Albany, Cal., Western regional research laboratory, 1950. 5 p. (processed) (U.S. Department of agriculture. Bureau of agricultural and industrial chemistry. AIC-274)

CONSERVATION OF RESOURCES

43. United nations scientific conference on the conservation and utilization of resources, Lake Success, 1949. Volume 1, plenary meeting. Lake Success, N.Y., United nations. Department of economic affairs, 1950. 431 p.
44. Ponds for fish and wildlife production. n.p., Missouri conservation commission, n.d. 32 p. il.

CROPS

45. American barley production; a study in agricultural geography. John C. Weaver. Minneapolis, Burgess publishing company, 1950. 115 p. figs. (processed) Bibliographical footnotes.
46. The soybean as a grain crop in Ontario. I. M. Roberts and G. P. McRostie. Toronto, 1950. 19 p. il. (Ontario department of agriculture. Bulletin 474)
47. Le millet et autres récoltes auxiliaires. Québec, n.d. 15 p. il. (Québec. Ministère de l'agriculture. Circulaire G.C. no. 9)

DAIRY INDUSTRY—DAIRY RESEARCH

48. Laboratory manual; methods of analysis of milk and its products. 2d edition. Wash., Milk industry foundation, 1949. 629 p. il. tabs. References at end of each chapter.
49. Practical dairy bacteriology. Paul R. Elliker. New York, McGraw-Hill book company, inc., 1949. 391 p. figs. tabs. References at end of each chapter.
50. Connecticut dairymen's association. Report of proceedings of the 69th annual convention, Morris, Conn., 1950. Meriden, 1950. 132 p.
51. Contribution à l'étude de l'influence des bactéries lactiques sur la teneur en thiamine et en riboflavine du lait. René Riel. La Trappe, 1949. 57 p. (Institut d'Oka. Contributions. No. 6)
52. New York state association of milk sanitarians. Twenty-third annual report, 1949. Albany, New York state department of health. 188 p. il.
53. American dry milk institute, inc. Proceedings of the 25th annual meeting, Chicago, 1950. Chicago, 1950. 87 p. (processed)
54. The market-milk industry. Chester L. Roadhouse and James L. Henderson. Second edition. New York, 1950. 716 p. figs. tabs. References at end of each chapter.

ECONOMIC POLICY

55. The Midyear economic report of the President, July, 1950 together with a report to the President, The economic situation at midyear, by the Council of economic advisers. Wash., 1950. charts. tabs.
56. Point four: Cooperative program for aid in the development of economically underdeveloped areas. Wash., 1950. 167 p. charts. tabs. (U.S. Department of state. Publication 3719. Economic cooperation series 24)
57. Wartime economic planning in agriculture . . . Bela Gold. New York, Columbia university press, 1949. 594 p. Bibliographical footnotes. (Columbia university. Faculty of political science. Studies in history, economics and public law. No. 551)
58. The Brazilian economy; chronic inflation and sporadic industrialization. Henry William Spiegel. Philadelphia, The Blakiston company, 1949. 246 p. tabs.

ECONOMIC SURVEYS

59. An economic and financial survey of farming in the South-West of England; a comparative study of an identical sample of 200 farms in the counties of Cornwall, Devon and Dorset, 1947/48 and 1948/49. S. T. Morris and H. W. B. Luxton. Long Ashton, Bristol, 1950. 63 p. tabs. (Bristol. University. Department of economics. Report no. 61)
60. Farm housing in the Northeast; a survey of facilities, activities, possessions, and preferences of families on owner-operated farms. Glenn H. Beyer. Ithaca, 1949. 458 p. tabs. (Cornell university. Agricultural experiment station. Memoir 292) (Northeast regional publication no. 1)
61. Woodlot economics on Vermont dairy farms. R. M. Carter. Burlington, 1950. 24 p. figs. tabs. (Vermont. University. Agricultural experiment station. Bulletin 554)

ECONOMICS—ECONOMIC HISTORY

62. Economics and the public welfare; financial and economic history of the United States, 1914-1946. Benjamin M. Anderson. Toronto, D. Van Nostrand company, inc., 1949. 602 p. Bibliographical footnotes.
63. Economics with applications to agriculture. Edwin F. Dummeier, Richard B. Heflebower, and Theodore Norman. Third edition. New York, McGraw-Hill book company, inc., 1950. 718 p. figs. tabs. Bibliographical footnotes.
64. The economic theory of the cost of living index numbers. Melville J. Ulmer. New York, Columbia university press, 1949. 106 p. figs. (Columbia university. Studies in history, economics and public law. No. 550)
65. Human action; a treatise on economics. Ludwig von Mises. New Haven, Yale university press, 1949. 889 p. Bibliographical footnotes.

ENGINEERING

66. A rapid method for determining the moisture content of soils. Albert James Bonar. College Station, 1949. 15 p. figs. tabs. (Texas engineering experiment station. Research report no. 9)
67. Maintenance and operation of tillage machinery. Evan H. Hardy. Saskatoon, 1950. 23 p. figs. (Saskatchewan. University. College of agriculture. Agricultural extension bulletin no. 32) (Reprint with changes)
68. Lectures on foundation engineering. A. E. Cummings. Urbana, 1949. 142 p. figs. tabs. (Illinois. University. Engineering experiment station. Circular series no. 60)
69. The solvent extraction of oilseed . . . E. P. Cofield, jr. Atlanta, 1950. 103 p. figs. tabs. (Georgia institute of technology. State engineering experiment station. Circular no. 28)
70. American society of agricultural engineers, Pacific Northwest section. Proceedings of convention, Harrison Hot Springs, B.C., 1949. v.p. (processed)
71. Facts and figures on electricity for farm and home . . . by Agricultural engineering branch, Department of agriculture and marketing. Halifax, N.S., 1949. 9 p. (processed) (Publication 1010)
72. Construction of a milk cabinet and cooler. James S. Englund and others. Pullman, 1950. 28 p. figs. (Washington state institute of technology. Engineering experiment station. Bulletin no. 74)
73. Farm structures. H. J. Barre and L. L. Sammet. New York, John Wiley & sons, inc., 1950. 650 p. figs. tabs. References at end of each chapter. (The Ferguson foundation agricultural engineering series)
74. Farmhouse plans. Blacksburg, n.d. 33 p. (Virginia agricultural extension service. Bulletin 174)
75. Planning your milk house. A. N. Ouellette. Winnipeg, 1949. n.p. figs. (Manitoba. Department of agriculture and immigration. Publication no. 227)

FARM MANAGEMENT—FARM LABOR

76. An outline of economic principles in farm organization and management. A. H. Maunder. Oxford, 1950. 21 p. (Oxford. University. Occasional papers in agricultural economics. II)
77. Labor requirements for California crops; major seasonal operations based on estimated acreages and production for 1947. Sacramento, 1948. 19 p. (processed) (California. Department of employment. Farm placement service and Research and statistics section. Report 822, no. 1)

FEEDING AND FEEDING STUFFS

78. Feeding of livestock. Stephen J. Watson. London, Thomas Nelson and sons ltd., 1949. 325 p. tabs. plates.
79. Minnesota. Department of agriculture, dairy and food. Thirty-first annual feed bulletin, by H. A. Halvorson. St. Paul, 1949. 333 p.
80. The composition and feeding value of grass and clover. S. J. Watson. (Edinburgh) 1949. 16 p. (The Edinburgh and East of Scotland college of agriculture. Miscellaneous publication no. 41) (Reprinted from Transactions of the Royal Highland and agricultural society of Scotland, 1949)

FERTILIZERS

81. Fertilizer recommendations for Manitoba. The Manitoba fertilizer board. Winnipeg, 1949. fold. (Manitoba. Department of agriculture and immigration. Publication no. 222)
82. Hunger signs in crops; a symposium. Prepared by Firman E. Bear and others. Published by The American society of agronomy and The National fertilizer association. Wash., 1949. 390 p. figs. col. plates. References at end of each chapter.
83. Recommandations du conseil des engrais chimiques de la province de Québec pour l'année 1949. (Québec), 1949. 9 p. (Québec. Ministère de l'agriculture. IR 46-F)

FOOD

84. Canadian cook book. Nellie Lyle Pattinson. 20th edition. Toronto, Ryerson, 1949. 451 p. il. tabs.
85. Preparation of frozen foods. J. G. Woodroof and Ethyl Shelor. Experiment, 1949. 39 p. il. tabs. (Georgia experiment station. Bulletin 261)
86. Boneless beef study. Robert L. Graf. Chicago, 1949. n.p. (processed) (Quartermaster food and container institute for the armed forces. Interim report no. 1. Project, "Meats, Frozen.")

FORESTRY

87. Great Britain. Forest commission. Report on forest research for the year ending March, 1949. London, H.M. stationery office, 1950. 80 p.
88. The Swedish forest research institute's machines for measuring annual rings; their origin, construction and application. Stockholm, 1949-1950. 76 p. figs. (Sweden. Forest research institute. Vol. 38, 1949-1950. Report no. 5) English summary; 70-76.

GENETICS

89. Genetics of the fowl. F. B. Hutt. New York, McGraw-Hill book company, inc., 1949. 590 p. il. tabs. diagrs. References at end of each chapter.

HORTICULTURE

90. Making floristry your business. Angela Johnson. London, Vawser & Wiles, ltd., 1949. 102 p. figs.
91. The John Innes glasshouses. Edinburgh, Oliver and Boyd, 1950. 11 p. il. (John Innes leaflet no. 10)
92. Oregon state horticultural society. Forty-first annual report, Eugene, Oregon, 1949. 102 p.
93. Lawns; their preparation and care. F. J. Weir. Winnipeg, 1950. 8 p. (Manitoba. Department of agriculture and immigration. Publication no. 233)
94. A guide to potato production under irrigation in Alberta. Potato production improvement committee. Edmonton, 1950. 10 p. il. (Alberta. Department of agriculture. Field Crops Branch. Bulletin no. 2)
95. Small fruit growing in Alberta. R. J. Hilton and Olive D. Lancaster. Edmonton, 1950. 45 p. figs. (Alberta. University. Faculty of agriculture. Department of extension. Bulletin no. 54)
96. Strawberry growing in Manitoba. E. T. Anderson. Winnipeg, 1950. 4 p. (Manitoba. Department of agriculture and immigration. Publication no. 234)

HORTICULTURE—Continued

97. A second census of apple orchards in Nova Scotia. Prepared by the Horticulture and biology services branch. Halifax, Department of agriculture and marketing, 1950. 50 p. charts. tabs.
98. Floriculture; fundamentals and practices. Alex Laurie and Victor H. Ries. Second edition. New York, McGraw-Hill book company, inc., 1950. 525 p. figs. Bibliography at end of each chapter.
99. Vegetable gardening in Saskatchewan. C. F. Patterson. Saskatoon, 1950. 62 p. figs. (Saskatchewan. College of agriculture. Agricultural extension bulletin no. 95, reprint with changes)
100. Massachusetts horticultural society. Yearbook, 1950. Boston, 1950. 55 p. il.

INSECTS—PESTICIDES

101. Larvae of insects; an introduction to Nearctic species. Alvah Peterson. Part I. Lepidoptera and plant infesting Hymenoptera. Columbus, Ohio, 1948. 315 p. figs. (processed) Selected bibliography for larvae of lepidoptera: pp. 228-236. Selected bibliography for larvae of Hymenoptera: pp. 274-277.
102. A catalogue of the Hesperiidae from Europe, Asia and Australia in the British Museum (Natural history). W. H. Evans. London, British Museum, 1949. 502 p. col. pls.
103. Newer pesticides; formulations, hazards, precautions, compatibility. State College, 1950. 15 p. (Pennsylvania state college. Agricultural experiment station. Progress report no. 29)
104. Insects of the Alberta farmstead. E. H. Strickland and B. Hocking. Edmonton, 1950. 114 p. figs. (Alberta. University. Faculty of agriculture. Department of extension. Bulletin no. 55)
105. A digest of information on toxaphene. R. C. Roark. Wash., 1950. 82 p. (processed) (U.S. Department of agriculture. Bureau of entomology and plant quarantine. E-802)
106. Insects affecting forest products and other materials. W. J. Chamberlin. Corvallis, Oregon, O.S.C. cooperative association, 1949. 159 p. il. (processed) References interspersed.
107. Air transport and insects of agricultural importance. W. A. L. David. London, Commonwealth institute of entomology, 1949. 11 p.
108. Introducing the insect. F. A. Urquhart. Toronto, Clarke, Irwin & company, ltd., 1949. 287 p. figs.
109. A device for transferring insects from holding cages to test containers. Robert A. Hoffman. Wash., 1950. 4 p. figs. (processed) (U.S. Department of agriculture. Bureau of entomology and plant quarantine. ET-288)
110. Structure and development of the reproductive system of some species of Nematocera (order Diptera: suborder Nematocera). S. E. Abul-Nasr. London, Cambridge university press, 1950. (Royal society of London. Philosophical transactions. Series B. Biological sciences. No. 614. vol. 234, 1950, pp. 339-396)
111. The mayflies of Florida. Lewis Berner. Gainesville, University of Florida press, 1950. 267 p. tabs. pls. (Florida. University. Studies. Biological science series, vol. IV, no. 4)

LAND SETTLEMENT—LAND UTILIZATION

112. Land settlement in Nova Scotia. Halifax, Department of agriculture and marketing, 1949. 23 p. il. (Publication 1004)
113. An economic report on submarginal land, Jefferson county, Oregon. C. V. Plath. Corvallis, 1950. 10 p. (processed) (Oregon state college. Agricultural experiment station. Circular of information 471)
114. Wildlife and good land use. Albany, 1950. 9 p. il. (processed) (New York state. Conservation department. Information bulletin no. 7)

LIVE STOCK INDUSTRY—BREEDING

115. Practical animal husbandry. Jack Widmer. New York, Charles Scribner's sons, 1949. 159 p. il. tabs.
    A complete guide to the raising, care and feeding of domestic animals and poultry.
116. The Western range livestock industry. Marion Clawson. New York, McGraw-Hill book company, inc., 1950. 401 p. figs. tabs. References interspersed.

LIVE STOCK INDUSTRY—BREEDING—Continued

117. Observations on Red Sindhi cattle. I. Breeding activities. II. The breeding efficiency. Thomas V. Rigor. (The Philippine journal of animal industry, vol. 10, no. 2, second quarter, 1949, pp. 143-154)
118. The breeding activities of grade Ayrshire cows. Thomas V. Rigor. (The Philippine journal of animal industry, vol. 10, no. 2, second quarter, 1949, pp. 155-161)
119. Sex determination of geese. Thomas H. Canfield. St. Paul, 1949. 6 p. il. (Minnesota. University. Agricultural experiment station. Bulletin 403)
120. Canadian society of animal production (Eastern section). Report of proceedings of the fourteenth annual general meeting, Kemptville, Ontario, 1949. 47 p. (processed)
121. The effects of temperature, humidity, air movement and solar radiation on the behaviour and physiology of cattle and other farm animals; a review of existing knowledge. J. D. Findlay. Kirkhill, Ayr, 1950. 178 p. figs. pls. References at end of each chapter. (Hannah dairy research institute. Bulletin no. 9)
122. Poultry association of Great Britain and Modern poultry keeping. Year book, 1950. London, The Association, 1950. 112 p.
123. Wisconsin sheep production and marketing. O. E. Krause. Madison, 1950. 51 p. figs. tabs. (Wisconsin state department of agriculture. Bulletin no. 301)

MARKETING—TRANSPORTATION

124. Problems in marketing. Malcolm P. McNair and Harry L. Hansen. New York, McGraw-Hill book company, inc., 1949. 718 p. exhibits.
125. New England research council on marketing and food supply. Proceedings of the annual meeting, Durham, New Hampshire, 1950. Boston, 1950. 113 p. (processed)
126. Marketing Massachusetts potatoes. Part I. Potato storage facilities. Robert A. Fitzpatrick. Amherst, 1950. 32 p. il. (Massachusetts. University. Agricultural experiment station. Bulletin no. 454)
127. National transportation policy. Charles L. Dearing and Wilfred Owen. Wash., The Brookings institution, 1949. 459 p. tabs. References through the text.

MONOPOLIES

128. Report of the Federal trade commission on the concentration of productive facilities, 1947 . . . Wash., 1949. 96 p. figs. tabs.
129. Report of the Federal trade commission on the merger movement; a summary report. Wash., 1948. 134 p. charts. tabs.

NUTRITION—VITAMINS

130. Clinical nutrition. Edited by Norman Jolliffe, F. F. Tisdall, and Paul R. Cannon, for the Food and nutrition board of the National research council. New York, Paul B. Hoeber, inc., Medical book department of Harper & brothers, 1950. 925 p. figs. col. pls. References at end of chapters.
131. Report of the Committee on nutrition. London, British medical association, 1950. 106 p. figs. tabs.

PHYSIOLOGY

132. The problem of fertility: proceedings of the Conference on fertility held under the auspices of the National committee on maternal health. Edited by Earl T. Engle. Princeton, N.J., Princeton university press, 1946. 254 p. pls. tabs. graphs. References at end of papers.
133. Human fertility . . . Edmond J. Farris. White Plains, N.Y., Author's press, inc., 1950. 211 p. col. front. pls. figs. tabs. References: pp. 201-204.

PHYTOPATHOLOGY

134. Investigations on the "leaf spot" disease of black mulberries caused by Septogloeum mori (Briosi and Cavara). R. E. Stewart. (The Royal society of Western Australia, inc. Journal, vol. XXXIV, 1947-1948, pp. 87-104)
135. Diseases of bulbous iris. Charles J. Gould. Pullman, 1950. 31 p. figs. (Washington state college. Institute of agricultural sciences, Extension service. Extension bulletin no. 424)
136. Physiologic and genetic studies with the stripe disease in barley. Coit A. Suneson. (Hilgardia, vol. 20, 1950, no. 2, pp. 29-36)

PRICES—COSTS

137. Contrasts in agricultural price policies. A. I. Marsh. Oxford, Institute for research in agricultural economics, 1950. 29 p. figs. (Oxford. University. Occasional papers in agricultural economics. I)
138. Price control: Government intervention or the free market? F. R. J. Jervis. London, Hutchinson's scientific and technical publications, 1949. 224 p. diagrs.
139. Comparative costs of grain storage on farms and in elevators. Adlowe L. Larson and others. Stillwater, 1950. 9 p. tabs. (Oklahoma A. & M. college. Agricultural experiment station. Bulletin no. B-349)

SOILS—SOIL CONSERVATION—IRRIGATION

140. Soils; their origin, constitution and classification . . . Gilbert Wooding Robinson. London, Thomas Murby & co., 1949. 573 p. figs. tabs. pls. Bibliographies at end of each chapter. (3d ed. rev.)
141. Soil survey of Grenville county. N. R. Richards, B. C. Matthews and F. F. Morwick. Issued by Experimental farms service, Dominion department of agriculture and the Ontario agricultural college. Guelph, 1949. 103 p. col. map. (Ontario soil survey. Report no. 12)
142. Irrigation trials in Western North Dakota. Arlon G. Hazen. Fargo, 1950. 34 p. figs. (North Dakota agricultural college. Agricultural experiment station. Bulletin 358)
143. An exploratory study of soil groups in the Belgian Congo. Charles E. Kellog and Fidelia D. Davol. Brussels, 1949. 73 p. il. tabs. Literature cited: p. 73. (Institut national pour l'étude agronomique du Congo belge. Série scientifique no. 46)
144. Conquest of the land through seven thousand years. W. C. Lowdermilk. Wash., 1950. 38 p. figs. (processed) (U.S. Department of agriculture. Soil conservation service. S. C. S. MP-32, slightly revised)
145. Greenhouse assay of fertility of California soils. H. Jenny and others. Berkeley. (Hilgardia, vol. 20, pp. 1-8, May, 1950, no. 1)

STATISTICAL METHODS

146. The design of experiments. Ronald A. Fisher. 5th edition. London, Oliver and Boyd, 1949. 242 p. figs. tabs.
147. Experimental designs. William G. Cochran and Gertrude M. Cox. New York, John Wiley and sons, inc., 1950. 454 p. tabs. (Wiley's mathematical statistics series)
148. Statistical techniques in market research. Robert Ferber. New York, McGraw-Hill book company, inc., 1949. 542 p. figs. tabs. Bibliography: pp. 413-430.

New Periodicals in Library:

Summary tables of biological tests sponsored by the Chemical-biological coordination center. Wash., National research council, Vol. 1, no. 1, 1949.

British journal of sociology. London, London school of economics. (Quarterly)